ILTION OF RIVERS

HOUT EMBANKMENTS

F. A. LEETE

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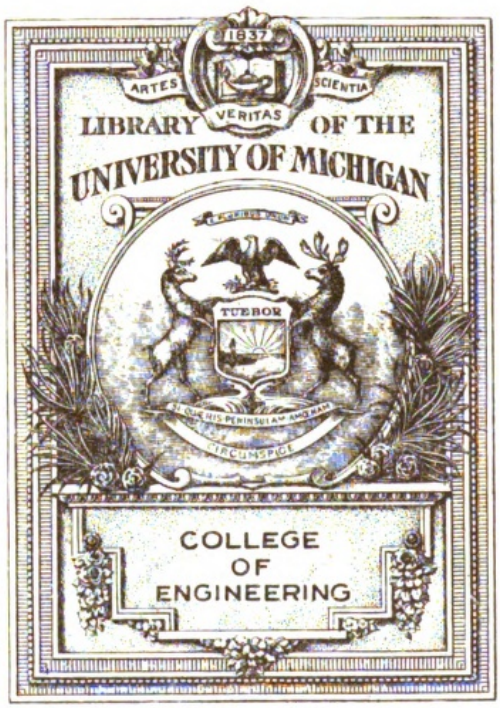

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REGULATION OF RIVERS WITHOUT EMBANKMENTS

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T. Marlow.

The Taungnyo Stream. A River Channel only Five Years Old.

December, 1923.

1. The 11-feet banks are entirely composed of the river's own deposits brought down from the hills since 1919.

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REGULATION OF RIVERS WITHOUT EMBANKMENTS

AS APPLIED IN

THE TRAINING WORKS

AT

THE HEADWATERS OF THE RANGOON RIVER, BURMA

(LOCALLY KNOWN AS THE MYITMAKA TRAINING WORKS)

BY

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The Extracts from Official Papers included in this book are published with the sanction of the Government of Burma

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1924

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PREFACE

THE original object in view in writing this book was to provide local Government officials with a full account of the Training Works at the headwaters of the Rangoon River, Burma. It soon became apparent, however, that the matter might be considered as being of far more than local or even of provincial interest. An attempt has, therefore, been made to present the subject in a form suitable for a wider circle of readers.

There would be no room for such publication if the Training Works had followed the usual lines. Regulation of rivers by means of embankments dates back to the dawn of history ; ancient and modern examples are to be met with all over the world. The point about the Myitmaka (Rangoon River) Training Works is that they dispense altogether with artificial embankments in the popular sense of the term. That rivers which, when in flood, bring down large quantities of sandy silt in suspension, do gradually build up banks for themselves is well known, but this fact never seems to have been taken anywhere as the basis for systematic training of streams other than as subsidiary to artificial embankments. The success which has attended the efforts to control the hill streams at the headwaters of the Rangoon River during the past eight years *without the use of any embankments at all* has been so remarkable, and the principles underlying the method can have such wide application, that the comprehensive title given to the book does not seem to be unjustified. **Regulation of rivers without embankments does deserve to rank as one permanent method of control along with regulation with embankments.**

Control without embankments cannot be effective with all kinds of rivers. It is only applicable to streams which start as hill torrents heavily charged with sandy silt. Such streams are everywhere subject to variations in flood levels, and in high floods overtopping of the banks is common. In tropical countries, with the greater part of the rainfall confined to half or less than half of the year, hill streams are torrential in character, and bank overflow is very frequent indeed. After every storm the streams come down in spate, and it is a common occurrence for the flood waters, after leaving the hills and reaching the lower-lying parts of the plain, to spread far and wide over the country-side.

Even if the streams ran clear, as the current is checked by gradual reduction in the slope of the ground, their drainage channels would tend to throw off numerous branch channels. This tendency becomes much more pronounced, however, in cases where the streams carry a heavy burden of silt in suspension. In such cases the network of constantly changing channels becomes a conspicuous feature. The fertility of large tracts of country may be seriously impaired, because fields may be buried under silt or be wiped out of existence altogether by erosion ; and, instead of being a blessing to local inhabitants, the streams may be a serious menace to their prosperity. Measures for keep-

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ing such rivers under control would clearly be indicated, and it is now beyond question that the method in which embankments are practically dispensed with, as described in this book, would seem to offer the best promise of success.

The above description presents the case for regulation without embankments in its simplest form. The balance in favour of this method of regulation is even stronger in the case of the Rangoon River, because another factor not at all uncommon elsewhere, which complicates the problem by accentuating the deltaic character of the streams after they leave the hills, is in operation. The main river into which the hill streams flow is itself subject to a wide range of flood levels, owing to overflow into it from the Irrawaddy during the monsoon periods. As a result several hundred square miles of the Myitmaka valley are inundated for four or five months of the year. Deposition of silt brought down by the hill streams is therefore not confined to the immediate vicinity of the main river, but occurs upstream wherever a hill flood meets the inundations.

Although the Myitmaka Training Works were started by the Forest Department of the Government of Burma for the purpose of floating out teak logs, the operations have proved to be so remarkably successful in the protection of cultivation from flooding, and in the reclamation of low-lying and swampy land, that they would certainly be continued even if the rivers ceased to be of importance for logging purposes.

Early in 1916 a report by me was printed under the title of " River Training Works in 1914 and 1915 for the Floating of Teak down the Myitmaka and its Tributaries in the Prome, Zigon and Tharrawaddy Forest Divisions." Later in the same year a supplementary note was printed. Instead of simply publishing a further supplement to the original book and note, it has been decided to replace them entirely, partly because so few copies of each were printed and partly with a view to presenting a better picture of the operations as a whole.

Discussion of a technical nature has been avoided as far as possible. The observations recorded and the deductions made therefrom are such as have impressed themselves upon the Forest officers who have been in charge of the logging operations on the streams. Although our training before entering the service of the Government included a course of elementary civil engineering, and although many of us acquire a considerable amount of practical experience with regard to civil and mechanical engineering problems, none of us can claim to be qualified to discuss the technical side of river training works in general.

Grateful acknowledgments are due to Lieut.-Colonel Nethersole, I.A., Deputy Commissioner, Tharrawaddy, and to the late Mr. B. M. Samuelson, M.I.C.E., Executive Engineer and later officiating Chief Engineer, Burma. Without their assistance it would have been impossible to have made a start at all with the Training Works. In the difficulties which arose from time to time between the Forest Department and the local people it was largely owing to Lieut.-Colonel Nethersole's steady support that serious trouble never occurred, and that there are now no more ardent supporters of the Training Works than the villagers themselves.

The one outstanding personality in the operations is that of Mr. G. C.

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Cheyne, I.F.S. He has been intimately connected with them from the start, first as Timber Assistant and later as Divisional Officer, Myitmaka Extraction Division. It is no exaggeration to state that the splendid results obtained have been due entirely to Mr. Cheyne's untiring efforts. The work has been strenuous, conditions arduous and the responsibility heavy. Mr. Cheyne has proved himself times without number to be the right man in the right place. The Government of Burma does indeed owe to him a great debt, which will, I trust, find suitable acknowledgment in due course.

My own personal connection with the Training Works practically ceased when I went on long leave in December, 1916. I was absent from the country until 1919. I paid short visits to the streams in January, 1920, September, 1923, and January, 1924.

The book is divided into ten chapters. The first one is introductory, and gives a summary of (1) the problem presented by the Myitmaka and its feeders, (2) the earlier efforts to control the streams, and (3) the final solution of the problem as worked out in the past eight years. Chapter VII., in which the training without embankments is more particularly described, may well be read after Chapter I., as it sets forth the whole argument for giving the book its title. The other chapters consist chiefly of an analysis of the facts bearing on the problem of control.

References to logging are frequent and take up considerable space, but the story of the rivers is so closely interwoven with the story of the transport of the logs that it is impossible to separate them.

RANGOON,
March, 1924.

F. A. LEETE.

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LOCAL NAMES AND TERMS

Chaung, Choung	= Stream.
In	= Lake, swamp.
Kaing	= Elephant grass.
Kazin	= Field bund.
Laha	= Tract annually inundated.
Neap (of logs)	= Stock of logs in course of extraction.
Taik (of logs)	= Jam of stranded logs in the bed of a stream.
Taungya	= Shifting or temporary cultivation.
Thegaw	= Shallow part of a stream.
Thugyi	= Village headman.
Yo	= Water channel.
Yoma(s)	= Mountain(s).
Lakh	= 100,000.

"Shwele," "Paungde," "Myole," etc., are pronounced "Shway-lay," "Paung-day," "Myo-lay," etc., "Thegaw," "Thay-gaw."

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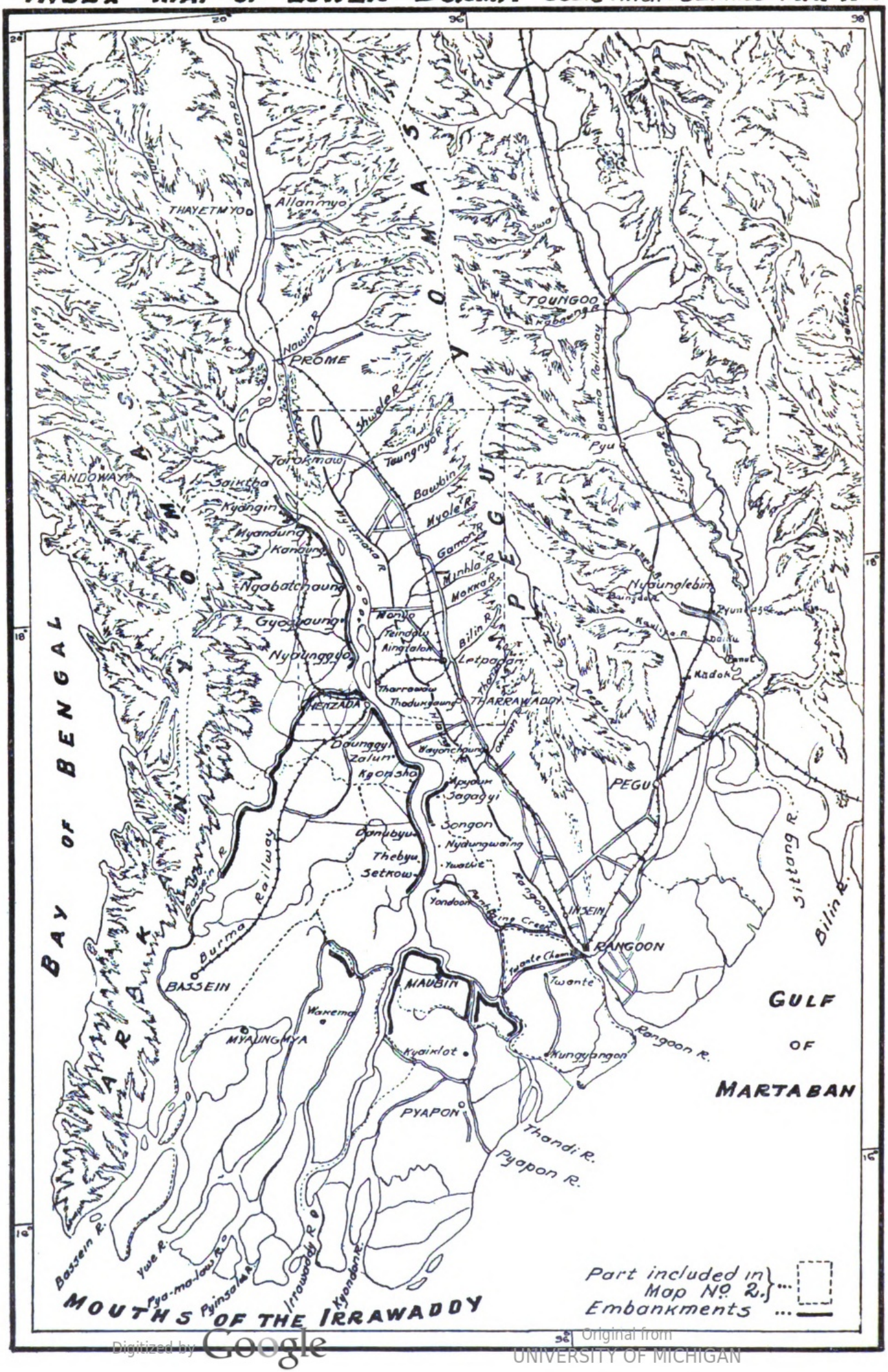
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PEGU YOMA
SAGAING
MAGWAY
MANDALAY
THAYETMYO
Allanmyo
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Kyaukkyi
Kyaukkyi
Kyaukkyi

MYITMAKA RIVER TRAINING WORKS, 1914—1923

CHAPTER I

INTRODUCTORY

THE PROBLEM IN 1914

1. Topographical Features.—Running down the middle of Burma is a range of mountains known as the Pegu Yomas, which forms the watershed between the Irrawaddy and Sittang Rivers. The hills have an extreme elevation of about 2,500 feet. South of the town of Prome the streams which take their rise on the western slopes of the range do not empty themselves directly into the Irrawaddy. The intervening plain is about twenty-five miles wide and is drained by a main stream known as the Myitmaka or Rangoon River and believed to have been an ancient channel of the Irrawaddy. It flows in a southerly direction more or less parallel to and about five miles distant from the latter. From its source down as far as Rangoon the Myitmaka has a length of about 210 miles.

The Yomas are composed of very friable sandstones and shales. The rainfall varies between 60 and 120 inches, and the greater part is precipitated during the monsoon, which lasts for about six months, viz., from the middle of May to the middle of October. During this period the hill streams come down in high flood at frequent intervals, bringing with them immense quantities of sand and clay in suspension.

2. Trouble with Logging.—The streams with which this book is more immediately concerned are the feeders of the Myitmaka in the upper half of its course, viz., one stream (Shwele) in the Prome District and eight streams in the Tharrawaddy District. The hill forests drained by this series of streams have been worked departmentally by Government to supply teak timber for the Rangoon market ever since the annexation of the Province of Pegu in 1852.

The writer was placed in charge of the Pegu Forest Circle early in 1913, and it was not long before his attention was directed to the departmental logging operations. Conditions with respect to them had been growing worse for many years. No matter how many logs were put into the streams in the hills, the number of logs which reached Rangoon annually diminished steadily, and it looked indeed as though the operations were in danger of coming to a standstill.

At their exits from the hills the streams had good channels, from 100 to 150 feet in width and from 20 to 25 feet in depth, but at varying distances out in the plain they rapidly deteriorated and more or less lost themselves in a network of shallow and branching channels. Very few logs found their way as far as the Myitmaka without assistance. The majority of them were left

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stranded in the various channels or were scattered about in intervening paddy fields. Retrieving the logs was a laborious business ; many of them had to be dragged for long distances by elephants. As there was very little in the way of European supervision, it need not be a matter for surprise that a good many logs were left behind. The number buried out of sight by detritus brought down by later floods was very large indeed.

The trouble with the rivers was of such long standing, and the streams had so persistently defied all attempts at control, that the belief was general that they were hopeless as a means of transport for timber, and that the sooner they were given up for logging purposes the better it would be for everybody concerned. In 1910 sanction was accorded to a project for stopping Shwele logs just below the railway bridge and sending them on to Rangoon by rail. It was thought to be merely a question of time for similar measures to be undertaken on all the other streams.

The writer paid his first visit to the streams below the railway early in 1914, to see what could be done to help local officers in getting out some, at any rate, of the large number of stranded logs, of which over 8,000 were known to exist. That was all the writer went for. The possibility of holding on to the rivers was an after-thought, but it soon became the chief thought. Careful study of the causes of trouble from a logging point of view gave rise to the belief that the rivers were nothing like so hopeless as was commonly supposed.

EARLIER EFFORTS TO SOLVE THE PROBLEM

3. Earlier Training Works.—Although the training works during the past ten years have been so successful, it would be doing scant justice to former generations of foresters and engineers to make no reference to their efforts at improving and controlling the streams. The rivers have been the subject of discussion for over sixty years. Attempts to control them began soon after this part of Burma came under British rule in 1852, and have continued from time to time ever since (*vide* the extracts from old official papers in the last chapter of the book).

The first extract is from Mr. Gordon's classic " Report on the Irrawaddy " in 1879. Then comes a Note by Lieut.-Colonel Scott-Moncrieff, Chief Engineer, Burma, in 1882. Last of all are the proposals for training the Taungnyo stream by means of embankments which were put forward by the Public Works Department in 1895 and 1903 respectively. If it had not been for want of space, the series of extracts could usefully have been extended by the inclusion of notes and suggestions by several of the foresters concerned with these rivers in the course of the past half-century.

The embanked and bridged road, ten miles long, from Paungde to Tapun was made at the same time as the railway, about the year 1867. Lieut.-Colonel Scott-Moncrieff's visit in 1882 was due to the existence of the railway being threatened, and to trouble with flooding by all the streams from Letpadan, on the Bilin stream, northwards to the Shwele stream in the Prome District. Although the Chief Engineer's suggestions were not carried out exactly as proposed by him, some protective works were undertaken at the time. For example, the Taungnyo stream was double-embanked for four and a quarter miles above the railway and a quarter of a mile below it ; the Bilin stream was

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2. View in sixth mile from railway looking downstream; *laha* on both sides, broad strip of permanent cultivation on both banks.

3. View in the seventh mile from railway looking downstream, showing formation of channel down to the *thegaw*; the *laha* extends across the picture in the distance; note partially flooded character of banks.

October, 1923. B. D. Lloyd.

Panoramic Views of the Minhla Stream.

[*To face p.* 2.

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double-embanked from the P.W.D. road down to the railway, thereby protecting the road, the railway and the town of Letpadan itself. These embankments were certainly effective in putting an end to the trouble in their immediate vicinity.

Thirteen years elapsed before anything more was attempted. In 1895 the Executive Engineer, Tharrawaddy, put up proposals for the embankment of the Taungnyo stream, but they came to nothing. In 1903 one of his successors put forward a similar project, which met with no better fate. This was the last effort of the Engineering or Public Works Department. The old Paungde-Tapun road was abandoned, and the P.W.D. ceased to take an active interest in the streams. The idea of getting the rivers under general control with a view to the protection of cultivation was to all intents and purposes abandoned as hopeless.

It is true that the Forest Department still continued to take an interest in the streams for the transport of its logs, but this interest can only be described as perfunctory. Forest officers rarely visited the rivers below the railway; nobody dreamt of studying them. This being so, it need not be a matter for surprise that the streams took advantage of this neglect to become worse than ever. Logging operations became more and more severely handicapped, and, as already remarked, about the year 1910 steps were taken to abandon the rivers for the floating of timber and to substitute transport by rail.

This swing of the pendulum was all the more noteworthy because the late Mr. Ellis, I.F.S., made an extended tour of the rivers in 1909, and if his suggestions had been carried into effect in full the rivers would certainly have been closely studied, and it is only reasonable to suppose that this study would have led to the same conclusions as were arrived at in 1914. His proposals for the embankment of the Taungnyo were given no consideration whatever at the time. Only one of his suggestions was carried out, viz., the diversion of the mouth of the Bawbin stream in 1910–12. A detailed account of this project is given in Chapter VI.

THE SOLUTION OF THE PROBLEM

4. Steps in the Evolution of the Solution.—Judging from the efforts made by them, the one and only idea of road and railway engineers was to hold the rivers in completely by means of embankments. Nothing else was thought possible, and the writer came to a similar conclusion in 1914. The first impression derived from his tour of the streams was that the most effective way to improve matters would be to double-embank the channels at the places where, owing to the smallness of the channels, side spill became conspicuous. This view was confirmed after consultation with the late Mr. Samuelson. High embankments were, therefore, made at critical places on four of the streams before the Rains in 1915, viz., one mile on the Shwele, three miles on the Taungnyo, half a mile on the Bawbin, and one and a half miles on the Minhla.

These measures were successful inasmuch as the embankments extended the good channels corresponding distances downstream. Certain drawbacks, however, manifested themselves, and the cost was high. The idea

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suggested itself that better results might possibly be obtained by means of low embankments designed to contain only part of the flood water. The matter is discussed in detail in Chapter VII.; here it will suffice to state that the experiment was tried on the Taungnyo in 1916. In spite of certain serious defects which were disclosed, the results were distinctly good. Nevertheless, paradoxical as the remark may seem, we came to the conclusion that artificial embankments, either high or low, were superfluous.

The conviction forced itself upon us that equally good results could be obtained without any artificial embankments at all. Effect was given to this idea in 1917, with such encouraging results that the method was continued in subsequent years. Seven years have elapsed since the regulation of these rivers without artificial embankments was first systematically tried, and it is now beyond question that it has afforded the best possible solution to the problem which had defeated foresters and engineers alike for over half a century.

5. The Part played by the Sandy Deposits.—The crux of the problem is the disposal of the sandy silt brought down from the hills in such immense quantities by all the streams. Under any method of control based on confining the rivers by means of embankments this sandy silt is a constant source of trouble, *and is prevented from performing any useful function locally.* The only thing to be done with it is to help it on its way to the sea. If artificial embankments are dispensed with, the silt can be made to build up banks of such great width that the risk of diversion is reduced to a minimum. Moreover, the rest of the silt can be directed wherever required to fill up swamps and render low-lying ground culturable.

It took us three years to grasp the full significance of the above facts. The trouble with the rivers had by that time narrowed itself down to two main heads, viz. (1) obstructions in the channel and (2) unevenness of the banks. Any material floating down a stream becomes an obstruction when it gets stranded or is deposited in the channel. Logs, trees, bamboos and rubbish generally come under this category, and also sandbanks created by the river itself. An additional form of obstruction of a very pernicious kind was only too common in 1914, viz., fishery weirs. The prohibition against them was subsequently made effective. Under the term "unevenness of the banks" are included irrigation cuts and cart tracks as well as natural depressions. If obstructions are removed from the bed, and if a small leading channel is dug across shallows (locally known as *thegaws*), there will be every inducement for a river to keep to its old channel when the next rise takes place. If the banks are dressed level, when flooding does occur the overflow will be uniform. An even layer of sandy silt will be deposited for a considerable width on both sides, thereby raising the banks to a corresponding extent. In this way, each flood may be expected to improve the channel by increasing its section and reducing the danger of diversion.

In addition to the removal of obstructions in the bed, the problem resolves itself into the question, How can bank deposition be promoted? The answer is, By bamboo stake fencing.

This remarkably effective solution to the problem of these rivers probably escaped notice for so many years owing to its extreme simplicity. That the

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March, 1924. G. C. CHEYNE.

THE MYOLE STREAM.

4. Preparations for the Rains, 1924, in the tenth mile, looking downstream ; logs herring-boned and stake fencing.

March, 1924. J. A. V. WELSH.

THE YENWE STREAM.

5. View looking downstream from the left bund, two miles below the railway ; the bed of the stream is as high as the ground level outside the embankment ; the banks of the stream are several feet higher.

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germ of the idea had existed for a very long time can be shown by reference to para. 106 of Gordon's "Report on the Irrawaddy" (page 99). In the extract therein given from a letter written in 1877 by Mr. Weidemann, Deputy Commissioner, Tharrawaddy, is the remark that—

"The plan now advocated is to run parallel with the stream a cheap and close fence along the inner side of which, during the overflows, a natural embankment of silt will be formed by the operation of the current. That silt will thus form is proved by experience. . . . When silt has once formed in sufficient thickness the fence will have done its work."

If the words "and close" be omitted, and for the words "along the inner side" the words "along both sides" be substituted, the above quotation would fit in exactly with more recent experience.

Although Gordon handed on the foregoing suggestion, he certainly did not realise its significance, because he himself continued to advocate the training of the streams by means of embankments. The idea remained dormant for another thirty-seven years; it was not until 1916 that it showed signs of growth, and that its value was demonstrated by practical application.

The writer has tried in the preceding paragraphs to indicate the main outlines of the picture as unfolded in 1914 and subsequent years. The forest officers looked at the rivers primarily as a means of transporting their logs, but that good would result to cultivation by bringing the rivers under control was realised from the start. Prominence was given to this probable outcome of the operations in order to enlist the sympathy of local civil officers. Experience has justified this optimism. Results could not have been better if the protection of villages and of cultivation from the destructive effects of uncontrolled flooding had been the primary objective. It may well, therefore, be claimed for the operations that they do afford a highly satisfactory solution of the problem from an engineering point of view.

6. Photographic Illustrations.—The photographs with which the book is copiously illustrated will, it is hoped, give a very clear idea of almost every phase of the Training Works.

The title of the frontispiece is no exaggeration. The picture is a view of the same part of the Taungnyo stream as the series of photographs in Plates 33 and 34. To eliminate a bad bend a leading channel 20 by 4 feet was dug in 1919 (*vide* Plate 33). In five years an excellent channel 65 by 11 feet entirely formed of deposits has been developed; swamp jungle has become permanent cultivation on both sides.

The panoramic pictures of the Minhla in Plate 2 give a very good bird's-eye view of a channel which does not date back earlier than 1919. The remarkably uniform manner in which ground levels have been raised is well brought out.

Photo No. 4 (Plate 3) is a view of the preparations just completed for helping the Myole stream to extend its good channel in the coming Rains (1924). Two miles upstream the river has a well-defined channel 48 by 7½ feet in section. The arrangement of the logs alongside the shallow depression down which it is desired to lead the river and also the lines of bamboo stake fencing on both sides are well brought out.

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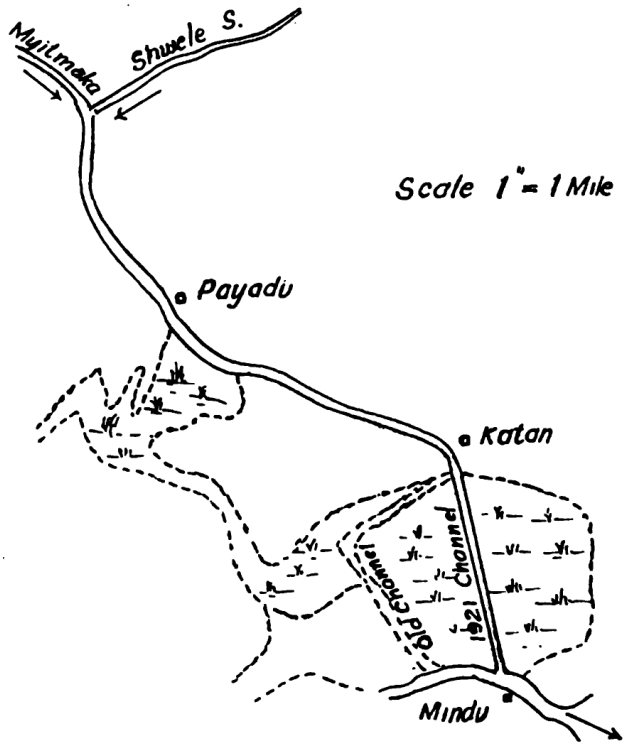
Photo No. 5 (Plate 3) is put in to illustrate the fact that the banks of a stream held in by embankments are raised above the level of the ground outside.

Photo No. 6 (Plate 4) is one of the most remarkable of the whole series. The picture was taken in January, 1924, from the right bank of the Shwele stream, looking across to the other bank, midway between Katan and Mindu (*vide* para. 82). The channel shown in the picture did not exist four years ago. The site was then nothing but a huge lake. The history of the channel is interesting. The Myitmaka further upstream simply emptied itself into the huge lake referred to, reappearing as a distinct channel at Mindu itself, three miles distant. The course taken by logs through the lake was, owing to obstructions, circuitous. Mr. Cheyne decided to straighten the track, and before the Rains began in 1921 he dug a leading channel through the sandbanks in the desired direction. As soon as logs were available they were arranged herring-bone fashion along both sides of this channel. These measures were sufficient to induce deposition, and banks began to form. In the course of three years they have raised themselves well above the ordinary flood level. In September, 1923, when the writer went up the channel in a launch, about a foot of the banks was showing. At the same time of the year in 1920 there would have been 15 feet of water everywhere. This fine channel is now a permanency. Overflow in the next few years may be expected to obliterate the remainder of the old lake appearing in the background of the picture.



CO-OPERATION IN MANAGEMENT

7. The essential features of the story of these rivers have been touched upon in the preceding paragraphs. The rest of the chapter is made up of local detail, which may not be of much interest to readers unacquainted with Burma, but it is included in this introductory chapter because the points are worth bringing to the special notice of officials and others living in the province.

Lack of Co-operation in Former Years.—Study of the history of this series of rivers brings out very clearly one thing, namely, that so little was accomplished in former years because of the lack of co-operation between the various departments of government concerned. Railway engineers thought of nothing but their railway, and hardly appear to have stepped off it. One engineer seriously gave it as his opinion that forest officers were to blame *for*

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January, 1924. F. A. LEETE.

SHWELE STREAM.

6. Formation of channel between Katan and Mindu ; 8-feet banks only three years old ; note *laha* water behind.

September, 1914. F. A. LEETE.

THE WEGYI DEPÔT.

7. View after a rise bringing down over 2,000 logs, which were stopped at the depôt by means of a floating boom of logs.

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not floating their logs by time-table. How ridiculous this appears if it is remembered that logs can only come down on the tops of floods, and that the latter cannot be foretold many hours ahead, and rarely last for more than a few hours. The streams were used for floating of teak logs even before the railway was built. It is nevertheless a fact that more than one of the bridges is unsuitable even to-day, owing to failure to give the requisite facilities for logs at high floods.

Road engineers thought of nothing but their roads, and rarely went off them. Revenue officers only concerned themselves with cultivation, and were only too ready to lay the blame for the damage done by floods on the logging operations of the Forest Department. In reading through old records it is rare to find any evidence of the various officers meeting to discuss matters. If they had done so more frequently they would have had more sympathy with each other, and there would have been more give-and-take between them. The problem to be solved was the same for all.

Closer Co-operation in Later Years.—The secret of the success which has attended the more recent efforts at training these streams lies entirely in the fact that there has been active co-operation throughout between the various interests concerned. After the writer's tour of the streams mentioned in para. 4 the next step taken was to try and enlist the sympathy of the civil head of the Tharrawaddy District. This was an easy matter, because Lieut.-Colonel Nethersole was himself anxious to have something done to protect villages and cultivation from the destructive effects of flooding. He had asked Mr. Samuelson to come over from Henzada and to advise him with regard to the village of Tapun. The writer was fortunate in being able to meet them there. Our discussion confirmed first impressions. It did seem possible to keep the Taungnyo stream to a definite channel, and by so doing to gain the end we were both striving for.

The previous history of the rivers had been so discouraging that it was extremely difficult to convince higher authorities of the possibility of doing anything of permanent use. Little was, therefore, accomplished in 1914. Only one thing done had any pretensions to being a work of permanent improvement, viz., the clearing of the Migyaungdin Yo, or Mingyi Chaung, as it was afterwards called (*vide* Photo No. 50 (Plate 26)). This work was such an unqualified success that it was in itself sufficient to change the whole face of the problem. It showed how the main Myitmaka could be regulated and improved, should occasion require, at any time in the future.

The Rains, 1914, were kind ; the outturn of logs was good, and the cost was moderate. The writing of a report at the end of the year was a pleasant task. The reward was worth the trouble. It was very gratifying to all the officers who had worked so hard to make things a success to find the Government of Burma so far convinced of the practicability of the proposals to train the rivers as to be prepared to accord sanction to more ambitious proposals put forward for the following year (1915). Expert advice by a professional engineer was asked for. The request was granted, and Mr. Samuelson made a tour of the streams in February, 1915. He believed in the soundness of the writer's proposals and worked out details. Sanction was accorded to the necessary expenditure, and the big embankments on the Shwele, Taungnyo,

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Bawbin and Minhla streams were an accomplished fact when the Rains began in May of the same year.

The Need for a Continuance of Co-operation in the Future.—Eight years have gone by, and the regulation of these rivers has passed beyond the stage of experiment, and has become such a simple matter that it attracts very little outside attention. It is nevertheless highly desirable that civil officers should continue to keep in close personal touch with the forest officers in charge of the Training Works. The writer would go even further, because he believes that it would be in the best interests of the Government to appoint as a permanency a civil officer to share with the forest officers in the management of these streams. There is plenty of room for such an appointment if the maximum benefit to cultivation is to be obtained. It cannot be obtained otherwise.

The importance of the matter can be better appreciated after perusal of the remarks made later on, not only about the reclamation of unculturable land, but also regarding the use of the streams for the irrigation of permanent cultivation. Great as is the value of these rivers for the floating of teak timber, even greater importance should attach to securing the maximum benefit from them to agriculture. The prosperity of the whole countryside is involved. The people are quite incapable of reaping the full benefit from the rivers for themselves. Active assistance in full measure by Government is clearly indicated.

LAND RECLAMATION

8. Amount of Silt brought down cannot be reduced.—Prominence may well be given to the fact that rivers such as these call for close attention even though there are no logging operations in progress on them. It is not a matter of reducing the amount of silt brought down by the rivers; nothing appreciable in this respect is practicable, because training works in the hills, such as are carried out in France and Switzerland, are out of the question. As the silt is bound to be dropped somewhere, if it does not reach the sea, the amount of land reclaimed will eventually be much the same whether any control is exercised over the rivers or not. The need for regulation must, therefore, be looked for in another direction. It lies in the protection of cultivation and villages whilst deposition and reclamation are in progress. If floating obstructions are not removed, and if the tapping of the streams for irrigation and the blocking of channels by fishery weirs are not looked after, the streams are bound to change their course at short intervals and without warning. Promiscuous flooding is sure to follow, with resultant loss to crops and inconvenience to villagers generally. The area actually cultivated will be less than if there were greater security. Land revenue will, therefore, suffer.

Land Reclamation.—The amount of reclamation that is steadily taking place may come as a surprise to many people. The seven streams from the Shwele to the Mokka inclusive drain an area of 560 square miles in the hills. The silt brought down by them in the eight years since 1915 has been sufficient to render culturable an area of not less than 10,000 acres of swamp land, and reclamation is progressing steadily at the rate of not less than two square miles per annum. If conditions are not upset artificially, there is no reason why progress with reclamation should not continue year by year until the whole of

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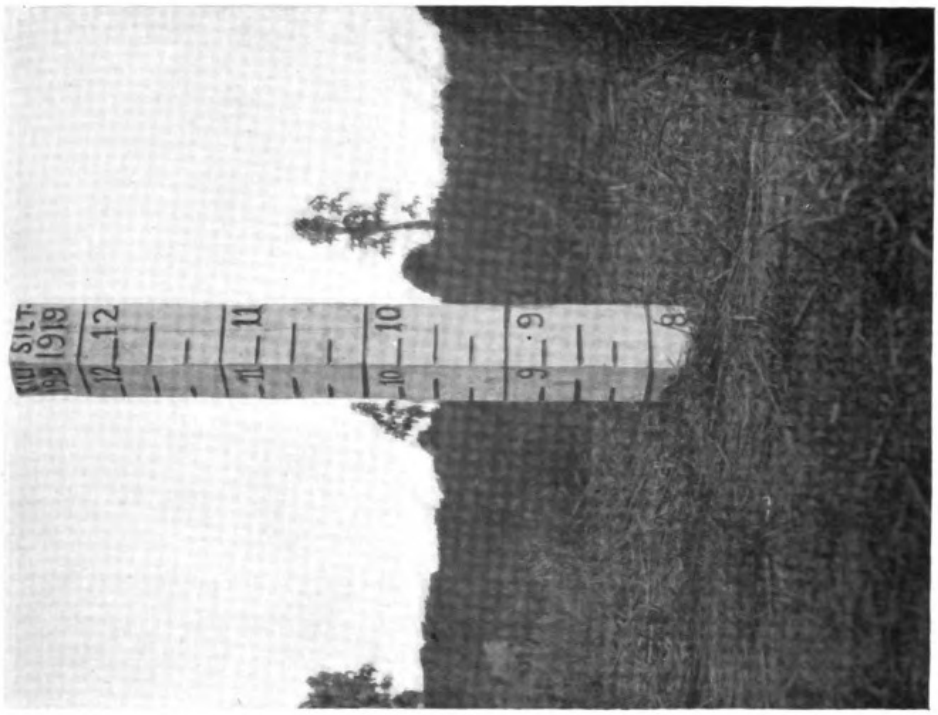
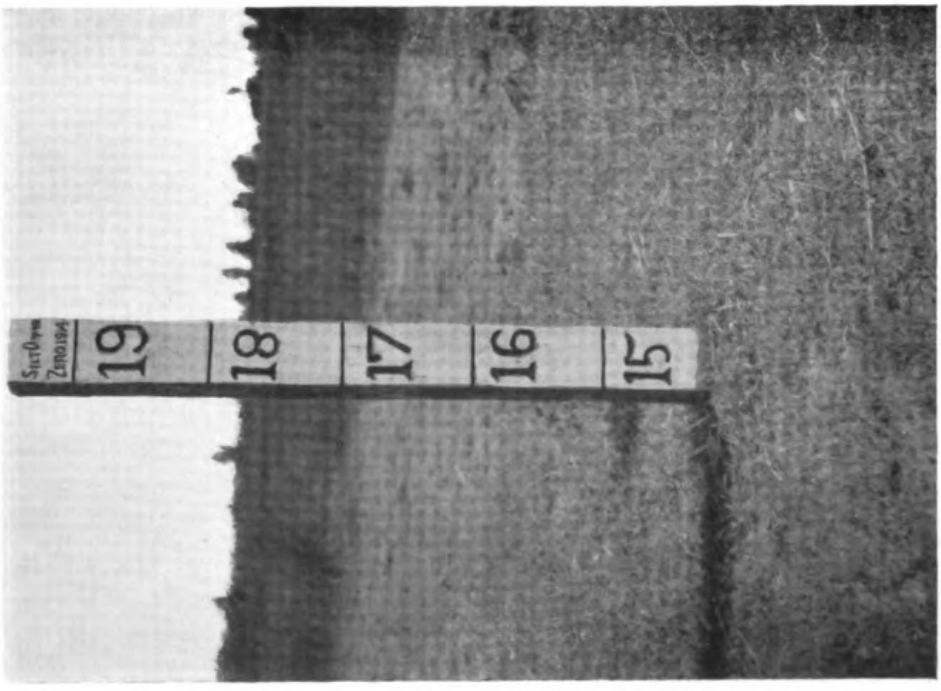


December, 1923. D. B. LLOYD.

TAUNGNYO STREAM.

9. Gauge post in fifteenth mile from the railway, showing 7 feet 6 inches of deposit since 1919.



December, 1923. B. D. LLOYD.

TAUNGNYO STREAM.

8. Gauge post in fourteenth mile from the railway, showing 14 feet of deposit since 1914.

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the low-lying country along the Myitmaka (locally known as *laha*) has been raised above ordinary flood level and has thereby become culturable. The flooded area is about 650 square miles in extent.

LOGGING OPERATIONS

9. The floating of teak logs from the forests to seaports is so universal in Burma, and is looked upon as such a simple operation, that it would at first sight appear to be superfluous to go into any lengthy description of it. Still less would there appear to be room for doubting the financial soundness of continuing to depend on floating for the extraction of teak timber. All the same, such doubts actually arose in the Prome and Tharrawaddy Districts about the year 1910. It is rather remarkable that the forests in these districts are those which the Forest Department has continuously managed departmentally for the maintenance of the supply of Government teak logs for sale by auction at the Government timber depôt, Rangoon. These auctions are one of the oldest institutions in the province.

One would have expected the Department to have retained the easiest forests for its own working. Perhaps the forests in question were once looked upon as such. The fact, however, remains that floating of timber from them to Rangoon has given rise to endless discussion during the past forty years, and about thirteen years ago it was seriously proposed to abandon the rivers altogether in favour of transport by rail. The description of the rivers and of the measures taken to control and improve them for the floating of timber may therefore be of general interest. The subject is certainly worth bringing to the notice of forest officers or agents of timber firms anywhere who are discouraged by the difficulties attendant on the floating of timber and are on the look-out for substitutes. Advocates of mechanical engineering in forestry may well take to heart one truth of general application, that is brought out in the story of these rivers, viz., **given a timber that will float, then no form of land or aerial transport can compete for cheapness with water transport, if the latter is possible at all.** The comparative costliness of working the scheme for transport by rail which was put forward, as compared with transport by these rivers, lay in the fact that the logs had to be railed for a hundred miles, whereas by river the logs only required special assistance for a mile or two. Within limits the most economical method must be the one which makes the most use of the floatability of the timber.

Difficulties with Floating.—It is a mistake to suppose that the difficulties in the way of the floating of timber, about which so much is heard nowadays, are of recent origin. They have always existed. The fact that only small works of improvement were ever undertaken, and that big projects, of which there were several in the past forty years, invariably met with lukewarm support and nearly all came to nothing, leads one to suppose that the drawbacks to floating were looked upon as irremediable, and that the rivers were thought to be uncontrollable. At first it did not matter much. The streams were only asked to carry a small number of logs. The Forest Department only paid for those logs that reached Rangoon, and nobody worried much about the logs that were lost on the way. In later years, owing to changes in the method of management and the increased scale of the operations, a change of opinion

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with respect to river transport gradually took place. The idea got abroad that the rivers were markedly deteriorating, and that the deterioration was inevitable. As a matter of fact, this was the very reverse of what had actually been taking place.

10. Floating discredited.—The reason for the mistaken idea then prevalent is not far to seek. Attention was focused on the large number of logs lost or delayed in transit without any serious attempt being made to get at the bottom of the trouble with the rivers. In a period of over ten years only one forest officer (the late Mr. Ellis, in 1909) ever attempted to study them on the spot. The scanty encouragement Mr. Ellis received from his departmental superiors might well have deterred any one from taking the slightest interest in the subject. This is the more to be regretted because Mr. Ellis' proposals for the Taungnyo stream at Tapun in 1909 were subsequently thought to be so sound that effect was actually given to them in 1915. Five years wasted !

It only needed a continuance of this neglect and the advent of local officers with a strong bent in favour of mechanical engineering for the rivers to be utterly discredited. Such was the state of affairs in 1909, when it was decided to abandon the Shwele stream and to instal a boom and depôt at Wegyi for rail transport to Rangoon. In 1912 similar proposals for the Kantha (Taungnyo) stream were put forward. In the same year a tramway was proposed for the Myaung stream. Every one thought that it was merely a question of time to see all the rivers abandoned in the same way. Nevertheless, within the short period of two years (1914–15) the tables were completely turned. It was proved incontestably that the erection of booms to hold up logs and the subsequent transport of them by rail were certain to be more costly than the training of the streams. As a result the Wegyi depôt was closed and dismantled, the Kantha project was dropped, and the Myaung tramway scheme was shown to be superfluous.

At first sight it would appear to be a comparatively simple matter to stop logs at any convenient place near a railway bridge, and to haul them out of the river for transport by rail. Appearances are often deceptive, and never more so than in the subject under reference. The truly formidable nature of such projects as the Shwele one can be gathered from Photo No. 7 (Plate 4), showing what the river looked like at Wegyi after a rise bringing down some 2,000 logs. The task of handling masses of logs like this proved to be a heart-breaking one. It was repeatedly a case of working against time, as there was no telling when the next rise would take place or how many logs it would bring down. As time went on the situation became worse instead of better, owing to the steadily increasing size of the sandbank which formed in the bed of the stream on the near side, *i.e.*, on the same side of the channel as the depôt. The cost of handling the logs proved to be much more expensive than was originally estimated. Once systematic training of the rivers below the railway was taken in hand in 1915, experience soon showed conclusively that there was no case for mechanical projects of the Wegyi type.

Floating reinstated.—The rivers again came into favour, and have remained so ever since. It is certain that the new lease of life given to them, as carriers of logs, will be such a long one that the determination of the exact

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January, 1924. F. A. LEETE.

TAUNGNYO STREAM.

10. View of channel near Thakuttan; note the straw-coloured *laha* clay deposit as a layer about 3 feet thick along the bottom of the bank.

January, 1924. F. A. LEETE.

MINHLA *LAHA*.

11. High flood mark on tree 12 feet up; ground covered with rich silt and recently hoed up for planting gram.

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length of the period—if there is one at all—is of no immediate importance. So far as is known at present, transport by these rivers is by far the cheapest method, even if year by year all expenditure on training works is charged against the log outturn of the year. The rivers can be dropped at any time in the future and yet show a balance on the right side for all the money put into them.

One reason why the rivers earned such a bad name departmentally was because of the demand they made on elephant power for moving logs. Contractors strongly objected to working elephants knee-deep in mud without good fodder and without a dry spot on which to rest or sleep (*vide* Photo No. 33 (Plate 17)). It may be stated with confidence that all this is now a thing of the past. Experience in 1914 and in subsequent years has proved conclusively that elephants need not be employed below the railway at all in the Rains. There is not the same objection to working them in the dry season; a few elephants are still required to collect stray logs and place them in position for floating in the following season.

Part of Chapter IV., on logging operations, is contributed by Mr. Cheyne. The writer is also indebted to him for most of the details throughout the book relating to the streams since 1916. In para. 37 general conclusions of great importance with regard to logging are discussed. The writer would strongly emphasise every point therein made. Engineers engaged in regulating rivers of similar character elsewhere **should insist on the standard set on the Myitmaka being maintained by timber firms concerned.**

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CHAPTER II

TOPOGRAPHICAL FEATURES

11. This book is more immediately concerned with the headwaters of the Rangoon River and its feeders in the Prome and Tharrawaddy Districts. The main stream has a variety of names in the different parts of its course. It is known as the Myitmaka River in Prome and Tharrawaddy, the Hlaing River in Insein, and the Rangoon River in the neighbourhood of Rangoon itself. It is interesting to note that the name "Myitmaka" means in Burmese the "uncontrollable river."

The distance between the source of the river in the Inma Lake, near the southern boundary of the Prome District, and Rangoon is about 150 miles, and measured along the stream about 210 miles.

Some fifty miles south of the Inma Lake and ten miles north of the Letpadan-Tharrawaw railway line is a big connecting link between the Irrawaddy and the Myitmaka, known as the Teindaw or Shwelaung Channel. It is chiefly above this channel that the river and its feeders have given trouble in the past thirty or forty years either with regard to the floating of timber or in the protection of cultivation from destructive floods.

The Teindaw is not the only important connection with the Irrawaddy. There is another one, known as the Kwethe Yo, about twenty-five miles further north, and midway between Ngapigo and Baudigon (*vide* Map No. 2). Why these channels exert such a powerful influence is discussed later on in this chapter.

12. Source of the Myitmaka.—A line drawn eastwards from Prome town itself represents fairly well the northern limit of the drainage basin of the Myitmaka. North of this line the Pegu Yomas and the plains are drained by the Nawin stream, which enters the Irrawaddy at Prome. A low isolated range of hills (Talokmaw), about thirty miles long, runs due southwards from Prome. The plain separating this range from the Pegu Yomas is from ten to fifteen miles wide. The railway runs right round the northern end of this line of hills. The Public Works Department road leaves the railway at Paungde and crosses the range near the other end. Between the railway line and the road is a large swamp known as the Inma In,* collecting the drainage of the adjoining hills and the intervening plain. The outlet from this swamp is the Myitmaka.

The hill streams flowing into the Myitmaka from the Pegu Yomas are given on the next page.

All these streams are hill torrents with raised banks. Outside the hills they lose water rather than collect it. The drainage basin may therefore be taken in each case as limited to the hills. The overflow from these torrents into the adjoining plain and local rainfall are carried off by small local channels. The

* *In* or *Yo* = Burmese, lake or swamp.

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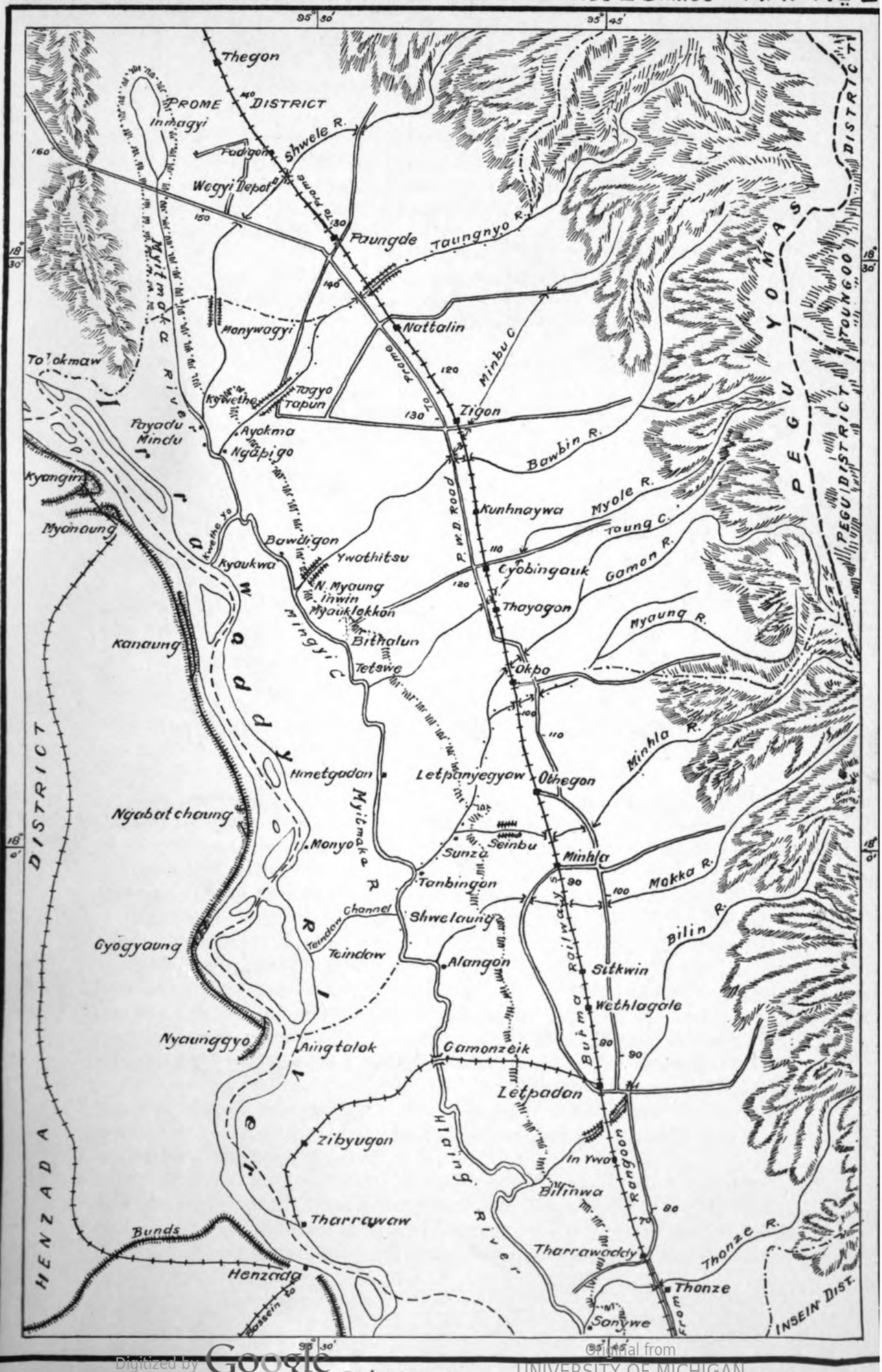
INDEX MAP OF THARRAWADDY DISTRICT Scale 1" = 8 miles MAP No. 2



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principal hill streams in the Insein District are entered in the table for the sake of completeness, although no further reference will be made to them, as they have not been studied. One of them—the Gyobyu—is known to have given trouble in logging operations in the hands of the private firm to whom the forests were leased until recently.

FEEDERS OF THE MYITMAKA

District.	Forest Division.	Stream.	Mileage from Rangoon at Railway Crossing.	Width of Plain.	Drainage Basin in Hills.
				Miles.	Sq. Miles.
Prome (Paungde Township) .	Prome (part).	Shwele (Wegyi) .	136	22	150
Tharrawaddy .	Zigon . .	Taungnyo (Kantha)	128	25	120
		Bawbin . .	118	25	90
		Myole . . .	106	25	50
		Gamon . .	102	25	50
	Tharrawaddy	Minhla . .	92	18	50
		Mokka . .	89	16	50
		Bilin . . .	76	16	120
		Thonze . .	66	13	160
Insein . .	Insein . .	Okkan . .	55	13	130
		Magayi . .	52	10	25
		Thabeyu . .	49	10	20
		Gyobyu . .	43	11	25
		Taikgyi . .	39	11	15

Effect of the Training Works.—From the remarks already made in Chapter I. it may be gathered that the state of affairs to-day is very different to what it was ten years ago. At the present time all the hill streams in Tharrawaddy are under practically perfect control, and there is no reason apparent why they should not remain so for an indefinite period.

What a contrast to the picture presented in 1914! All the streams—Shwele, Taungnyo, Bawbin, Myole, Gamon, Minhla and Mokka—were then totally beyond control, and had been so for such a long term of years that the impression was general that nothing at all could usefully be done to improve matters. Between the railway and the Myitmaka they were constantly changing their course. The logging operations of the Forest Department looked as though they would come to a standstill, owing to the loss of logs in transit and to the large expenditure incurred on those logs that did get through. Cultivation was severely handicapped by the vagaries of the streams; in the worst localities it was a common thing for the greater part of the paddy crop to be buried under huge deposits of silt.

13. The Laha.—Tradition has it that the Irrawaddy used formerly to flow between the Pegu Yomas and the Talokmaw Range and that the Myitmaka is merely the remains of an old bed of the main river. Whether this was so or not, after passing the southern end of the Talokmaw hills the Myitmaka comes

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directly under the influence of the Irrawaddy. There are several connecting channels by which Irrawaddy water flows into the Myitmaka every Rains, the most important being the Teindaw Channel and Kwetha Yo, already mentioned. Every year practically the whole of the intervening country is flooded, as well as a considerable area on the left bank or east side of the Myitmaka. *Laha* is the local name for the tract of country thus affected. This flooding lasts for so many months and submerges the banks of the main stream and its feeders so completely that a large part of the Tharrawaddy plain may be pictured as a huge lake into which a number of hill torrents empty themselves throughout the monsoon period, which lasts from May to October.

Area of the Laha.—The actual area of the *laha* can only be guessed at, as it has never been properly surveyed. The details given in the various maps in this book make no pretensions to accuracy. They give a general idea, nothing more. Early steps should be taken to verify and improve upon the estimates given below.

The total area of the part of the Tharrawaddy District between the Rangoon-Prome Railway and the Irrawaddy is about 1,250 square miles. Permanent cultivation, including recent additions on which paddy is grown, although the land is not yet out of the reach of temporary flooding, is estimated at 625 square miles. Corresponding figures for the Paungde Township (Shwele stream), Prome District, are—total area, 150 square miles, and cultivation, 125 square miles. The *laha* in the two districts therefore amounts to something like 650 square miles.

The following are rough estimates of the amount of reclamation that has taken place in the eight years which have elapsed since the Training Works were started in 1915 (excluding the preliminary work done in 1914) :—

Stream.	Distance the limit of cultivation has moved downstream. Miles.	Area brought under cultivation. Acres.
1. Shwele	4	1,250
2. Taungnyo	3½	3,500
3. Bawbin	—*	250
4. Myole	4	1,000
5. Gamon	4¼	1,750
6. Minhla	2 (since 1919)	1,750
7. Mokka	1¾ (since 1919)	500
Total		10,000

The average of the past eight years is 1,250 acres a year brought under cultivation, or approximately two square miles.

For purposes of comparison with the above figures, reference may be made to Gordon's Report of 1879 (Chapter X.). In para. 132, referring only to the country between the railway and the Myitmaka, the flooded area north of Thonze (near the southern boundary of Tharrawaddy) is put at 500 square miles. In para. 136 the flooded area on both sides of the Myitmaka is estimated

* Lateral development, as cultivation along the Bawbin had already reached the Myitmaka prior to 1914.

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November, 1923. F. A. LEETE.

MINHLA *LAHA*.

12. Deep channel in *laha*, half a mile below the Gamon-Minhla junction, looking upstream. Photo taken after the *laha* had fallen, exposing the ground, but a strong flow of water still running, 15 feet deep in the channel.

January, 1924. F. A. LEETE.

MINHLA *LAHA*.

13. Same place as No. 12 looking downstream; two months later; only a few inches of water; high ground in the background.

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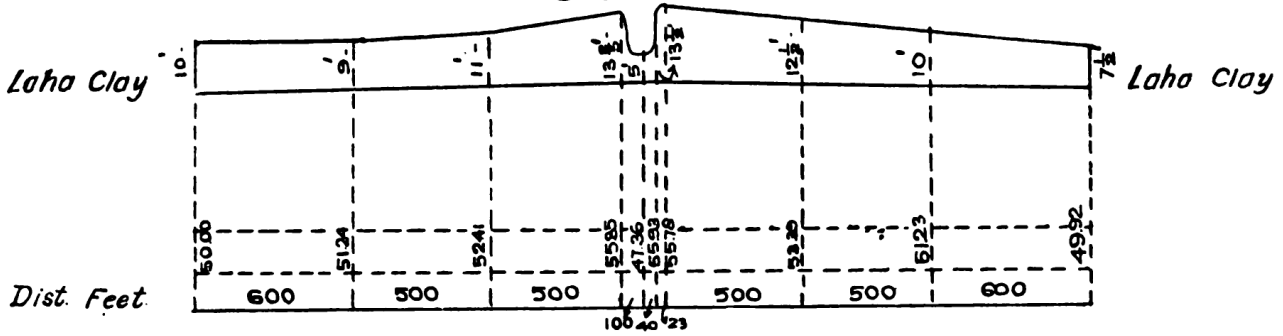
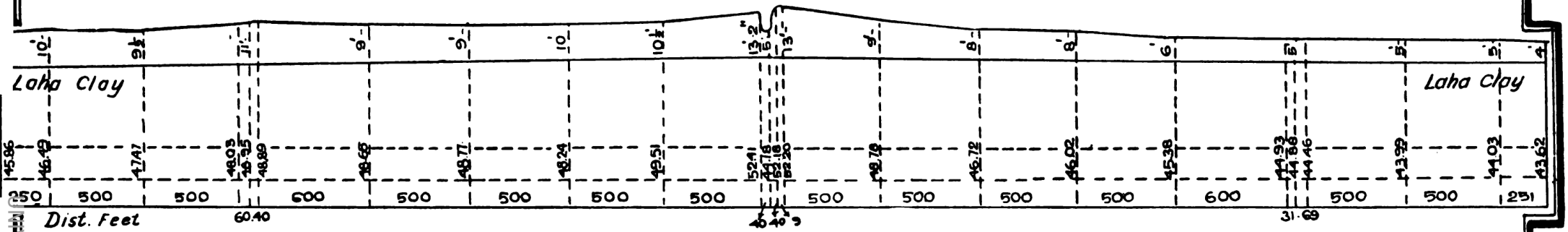
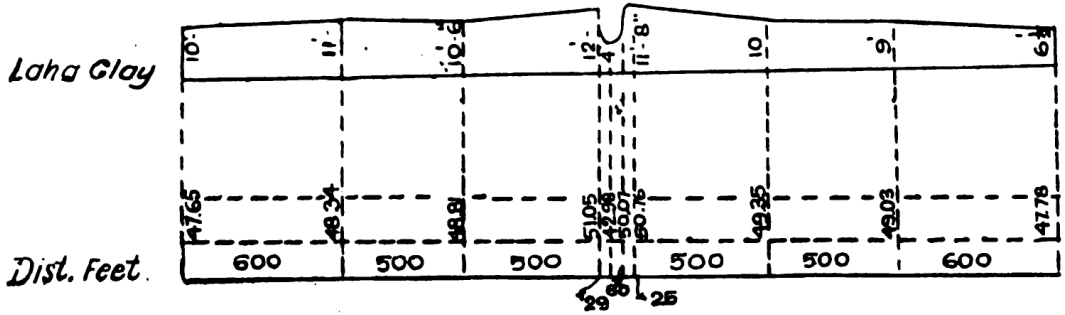
TAUNGNYO CHAUNG
1st Cross Section at Mile 13 (Zibingwe)
December 1922



TAUNGNYO CHAUNG
2nd Cross Section at Mile 14
December 1922



TAUNGNYO CHAUNG
3rd Cross Section at Mile 14½
December 1922



Horizontal Scale 1" to 800 Feet
Vertical Scale 1" to 40 Feet
Mileage from Railway.

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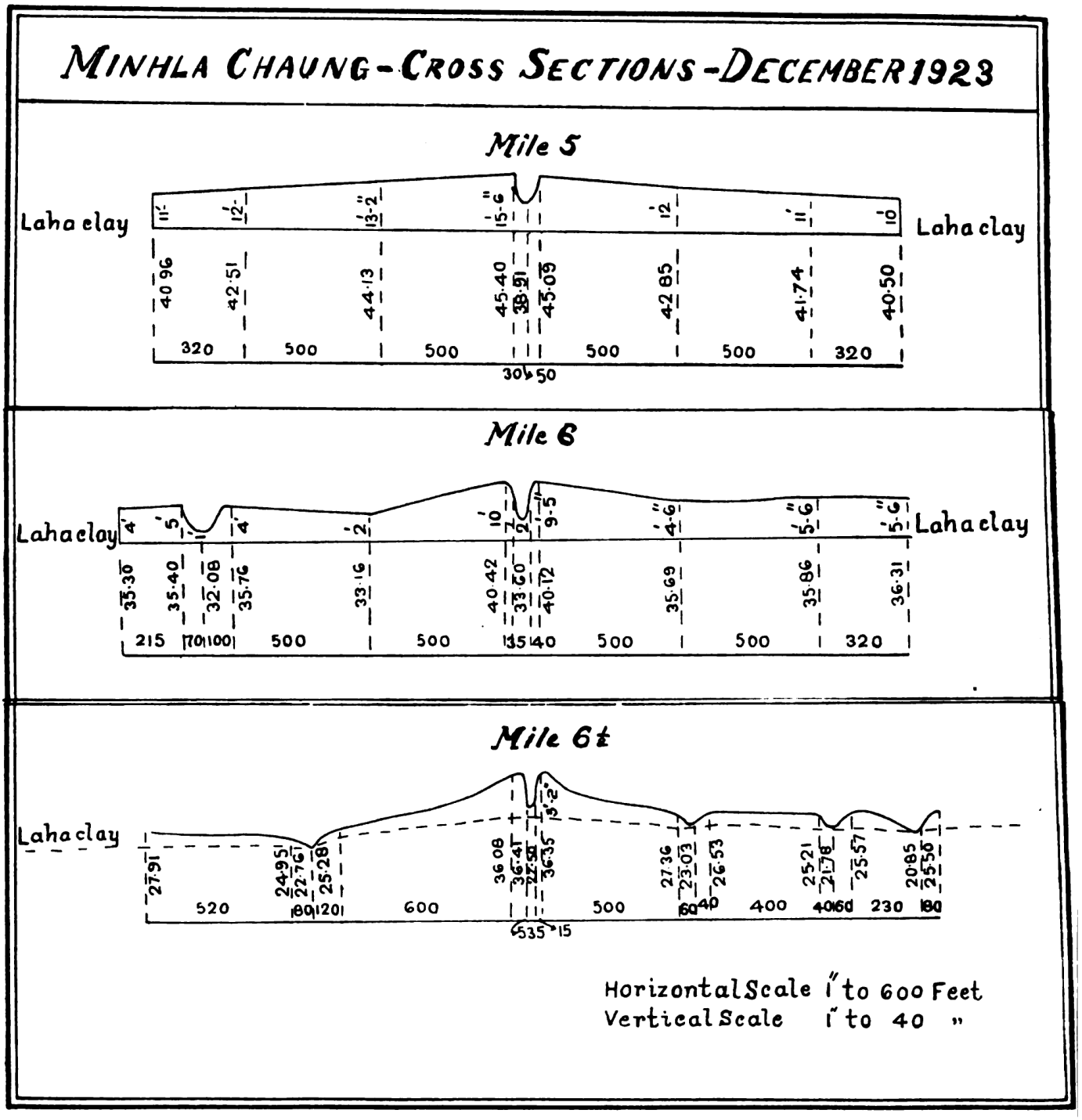
Fig. 2.



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at 1,200 square miles. The first figure appears to have been too small and the second one too large.

Gordon remarked that the floods reached close up to the railway line. The cultivated area could, therefore, not have been anything like the present figure of 750 square miles. It will probably not be far wrong to assume that an area of not less than 100 square miles has been reclaimed in the past half-century.

14. Composition of the Soil.—Three kinds of soil and subsoil are to be met with outside the hills, viz., (1) hard blue clay of unknown depth; above it, (2) a straw or buff-coloured clay deposit about 5 feet thick, above which in the cultivated plain is (3) the thick sandy deposit of which the surface soil is composed.

Throughout the plain traversed by these streams there is great uniformity in the character of the soil and subsoil, although there is a marked difference between the surface soil in the parts of the plain under permanent cultivation and in the low-lying tracts, known as the *laha*, which are annually inundated. The soil in the cultivated plain consists, as already stated, of sand with a certain proportion of clay irregularly mixed with it, but the sand predominates. The surface soil in the *laha* consists of straw-coloured clay with a slight admixture of fine sand. Digging to varying depths down to 20 feet or so anywhere in the cultivated plain will show that the uppermost sandy stratum varies in thickness from about 20 feet near the hills to next to nothing near the *laha*, and that underneath it is the same straw-coloured clay stratum that forms the surface soil in the *laha*. This layer is, in fact, continuous in both types of country. Its thickness varies from place to place, but it may be taken as being about 5 feet. Below it everywhere there is a substratum of hard blue clay of unknown depth.

The formation of these three strata is believed to have been as follows. The hard blue clay belongs to geological time, and is what one would expect to find at the bottom of a vast lake. The other two strata belong to recent times, and are nothing more or less than deposits brought down from the Pegu Yomas by the hill streams. By these deposits the level of the ground both in the cultivated part and in the *laha* has everywhere been raised in course of time. The ground level in the cultivated plain is now up to 20 or 25 feet higher above mean sea level than it was formerly, and in the *laha* something like 5 feet. Photos Nos. 8 and 9 (Plate 5) could be repeated on every stream in the series. They were taken on the Taungnyo stream; one shows 14 feet of deposit in nine years and the other 7 feet 6 inches in five years.

It is well known that a stream carrying sand and clay in suspension drops the former long before it is unable to continue to carry the latter. The sand, in fact, begins to drop when there is the slightest check to the current, such as occurs whenever a stream overflows its banks. The consequence is that the bulk of the sand is deposited close to the edge of the stream itself, and so the banks increase in height more rapidly than the plain further away. Hence arises the phenomenon of their raised banks which is so characteristic of these streams.

Assuming that it is quite correct to state that **deposits of sand are only to be found in close proximity to existing or former channels of the hill streams,** the remarkable uniformity of the ground level in the cultivated

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plain can only be explained on the supposition that the hill streams have wandered all over the area. As a matter of fact, this is what they have done. In modern times their wanderings have been the despair of everybody concerned, and there is no reason to suppose that in earlier times conditions were markedly different.

Before clay in suspension is dropped flood water has time to travel for long distances into the adjoining inundated country. The combined action of all the hill streams in this way affects the whole of the *laha ;* a thin layer of clay is deposited annually everywhere in it.

15. Formation of Stream Channels.—From the foregoing remarks it can readily be understood how the rivers form channels for themselves. It is not by scouring into the *laha* blue clay, but by building up banks out of their own deposits. As one travels downstream towards the *laha* the height of the banks steadily diminishes, but re-examination of the banks in any given locality after the lapse of a few years would invariably show that the bed had become deeper in the interval. It would indeed be more correct to say that the banks had become higher. The cross sections of the Taungnyo and Minhla streams in Figs. Nos. 1 and 2 (facing page 15) show clearly how the ground slopes away from the streams, and also that the bed of a stream may actually be higher than the original ground level some distance away. This brings out another detail. Although the writer has not come across any instances of scouring into the hard blue clay substratum, numerous instances have been noticed of scouring into the straw-coloured clay deposits resting on the blue clay. It may be stated that, as a general rule, the bed of a stream near the *laha* is higher than the adjoining country, because of sandy deposits in the bed itself. Travelling upstream, it may be noticed that the thickness of these sandy deposits increases, and that by the time permanent big channels in the cultivated plain are reached there are signs of scouring into the clay. Photo No. 10 (Plate 6) gives a good illustration of what can be met with on all the streams. The picture was taken at Thakuttan, on the Taungnyo stream, where the river had formed for itself a good and permanent channel fifteen years ago. Along the bottom of the bank, and reaching up to about 3 feet above the bed, a stratum can be noticed which is markedly different from the soil above it. Close examination showed that it was composed of straw-coloured clay with a slight admixture of sand.

The presence or absence of clay showing up in the bed of a stream can very well be taken as a reliable index as to whether the channel is improving or not. Sand in the bed at the lower end is only to be expected, and the same remark applies to the intermediate zone where the stream is actively engaged in building up its banks, but by the time bank deposition has practically ceased scouring into the clay should begin. As already remarked, this is a common feature of all the Tharrawaddy streams, and gives rise to the thought that they are improving, even though they lose large quantities of water through sluices, irrigation or general overflow. The recommendation is, therefore, made that periodical observation should be recorded as to the extent to which clay shows up in the beds of streams.

16. Raised Banks of Myitmaka and Irrawaddy.—The remark made in the preceding paragraph that ground levels are everywhere due to deposits

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December, 1923. T. MARLOW.

TAUNGNYO STREAM.

14. Old stump still *in situ* showing up in the bed of the stream near Ayokma ; banks 10 feet high, entirely composed of deposits since 1917 ; then dense jungle, now permanent paddy fields.

January, 1924. T. MARLOW.

TAUNGNYO STREAM.

15. Old stump still *in situ* at the big bend near Thakuttan ; note that the bed has been scoured 4 feet below the roots.

[*To face p.* 16.

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from the local hill streams is not quite correct, as it takes no account of the action of the Irrawaddy. Along the left bank of the latter the ground is higher than further in, and a certain amount of cultivation has existed there from the earliest times.

Similarly, along the banks of the Myitmaka there is high ground. It is not continuous. It shows up well at Mindu, near the old mouth of the Taungnyo, and locally all the way down. It is very striking near the outlet of the Gamon and Minhla streams at Tanbingon.

The origin of this high ground along the bank of the Myitmaka gives rise to speculation. It may have been formed when the Irrawaddy flowed in this direction, as it is supposed to have done once upon a time (para. 13). One thing is clear: the Myitmaka takes its rise in a swamp far away from the hills, and until quite recently the hill streams contributed no large amount of silt to it.

17. Deposits of Clay all over the Laha.—Evidence is easily forthcoming in support of the statement that clay in suspension is carried for long distances before being dropped. One has only to take a walk anywhere in the *laha* country in the dry season. The sensation is rather like treading on thin crackling ice or broken earthenware, as the open ground is covered with small rectangular cakes of dry clay about half an inch thick. They are evidently the sun-cracked deposits of the previous Rains, and a clear indication of the fact that the ground level all over the *laha* country is being steadily raised. Half an inch a year may seem to be hardly appreciable, but, continued for a century, it may amount to several feet.

The foregoing observation with regard to the rate of deposition in the *laha* generally was confirmed by what was noticed when the Training Works at Tapun were in progress in 1916. In that year a canal was dug, 4 feet deep, with low embankments on both sides. The ground was flat and covered with *kaing* * grass, and there were a few stunted trees dotted about. In the canal itself were several trees, and the excavation exposed a number of stumps that had been completely buried although still *in situ*.

Whilst the writer was on a visit to the Tapun Canal in April, 1916, a couple of trees were pulled over with a monkey winch. These trees were standing in the canal. Although 4 feet of soil had been removed, the trunks still had a straight and cylindrical appearance. The soil was composed of straw-coloured clay with a slight admixture of sand, of the same type, in fact, as is to be found all over the *laha* except in the vicinity of existing or former channels of the hill streams. The sides of the canal showed that the deposits were fairly uniform in character. The opinion formed from study of maps was therefore confirmed, viz., that no hill stream had ever flooded violently over the area and therefore that deposition had been gradual.

After the two trees in question had been pulled over two things were noticed: (1) a foot below the bed of the canal the soil suddenly changed to dark blue clay, and (2) the basal swelling and root system appeared. The inference drawn was that when these two trees began to grow the general level of the ground was from 4 to 5 feet lower than it was in 1916. One tree was hollow, but the rings on a section of the other one showed that the tree was from seventy to eighty years old. The inference drawn was that deposition in this

* *Kaing* = Burmese, elephant grass. (Grows 10 to 15 feet.)

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part of the *laha* began at least a century ago, and that the average since then has amounted to between ½ inch and ¾ inch per annum.

18. Deposition of Sandy Silt.—Stumps of felled trees still standing in their apparently original positions, but with the tops of the stumps several feet below the present ground level under sandy deposits, were a common sight in the beds of the streams soon after the Training Works were started. Although many have been subsequently removed, a few of them still remain and can be seen here and there. The writer noticed many such stumps in 1916. They were of the usual height and very much weathered, but the trees had evidently been felled. The roots were embedded in clay, although, when noticed, the tops of the stumps were 5 feet or more below ground level. It is only reasonable to suppose that the greater part of the deposition took place subsequent to the felling.

Photos Nos. 14 and 15 (Plate 8) are recently observed examples of buried stumps. No. 14 was taken near Ayokma in the fifteenth mile of the Taungnyo stream. The banks are entirely formed of deposits 10 feet high. The small stump just showing in the water is in clay, showing that the bed had scoured down to the latter. No. 15 was taken further up the same stream at Thakuttan in the tenth mile. The stump stands in clay deposit. At this point there is a sharp bend in the channel, and the bed has scoured right down to hard blue clay.

Photos Nos. 16 and 17 (Plate 9) are both of them of the same stump, the first one taken in 1919 and the other in 1924 near Ayokma, on the Taungnyo. The ground has been raised fully 3 feet in the interval, burying the root to this extent, and jungle has been replaced by permanent paddy fields.

Photos Nos. 18 and 19 (Plate 10) are of a tree growing close to the edge of the bank of the Taungnyo, near Ayokma, and with the trunk exposed to the roots. The shape of the bole and the gauge post show that the ground is fully 9 feet higher than when the tree began to grow ; as a matter of fact, the period of deposition has been much shorter than this ; no sandy silt at all reached here before 1916.

19. Deltaic Character of the Streams.—The behaviour of the Myitmaka and its feeders is deltaic in character. This is the key to an understanding of them—a key that was known about forty years ago, but subsequently lost sight of. In 1915 it was discovered again.

If the deltaic theory is correct, then old maps should show branching out of the streams much nearer to the hills than modern ones. This is the case. Two illustrations are given for the Shwele and Taungnyo streams (*vide* Map No. 3, facing page 19). One was taken from Colonel Fitzroy's map of 1862 ; the other is a sketch (based on local surveys) made in 1915. The only printed maps at present available were published in 1882. Although quite out of date and therefore unreliable, yet these old maps are very instructive. Deserted channels are indicated by lines of villages ; conversely, wherever the maps show a long string of villages it may be taken as certain that a hill torrent used to flow in that direction. This is as true of all these streams as it is of roads and railways in general.

In old correspondence about the Shwele stream attention was focused on the *Kya-In*—a big swamp into which the river used to lose itself, and

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July, 1919. T. MARLOW.

TAUNGNYO STREAM.

16. Big tree stump removed from the stream a short distance above the Ayokma Cut in the Rains, 1919.

January, 1924. F. A. LEETE.

TAUNGNYO STREAM.

17. The same stump as above nearly half buried beneath 3 feet of deposit; jungle has become permanent paddy field in four years.

[*To face p.* 18.

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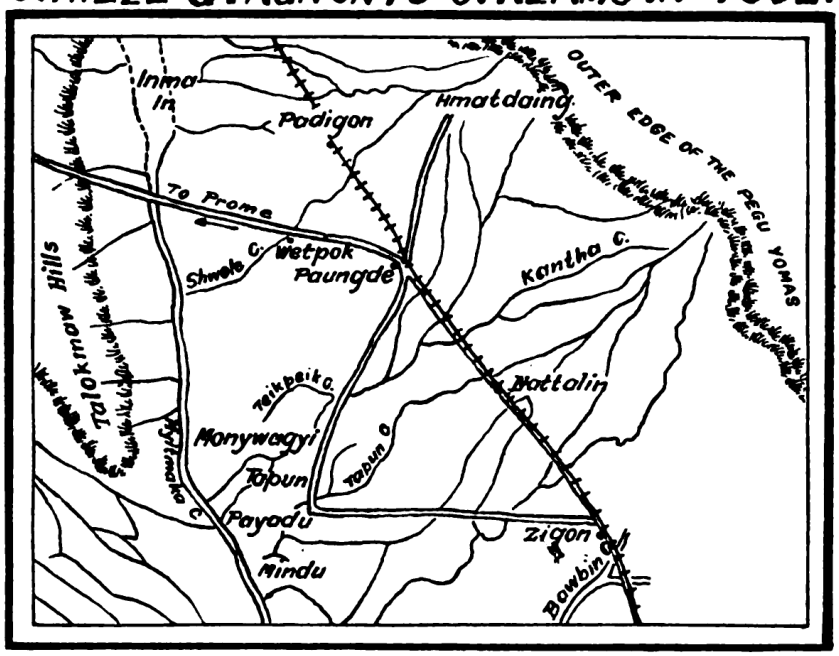
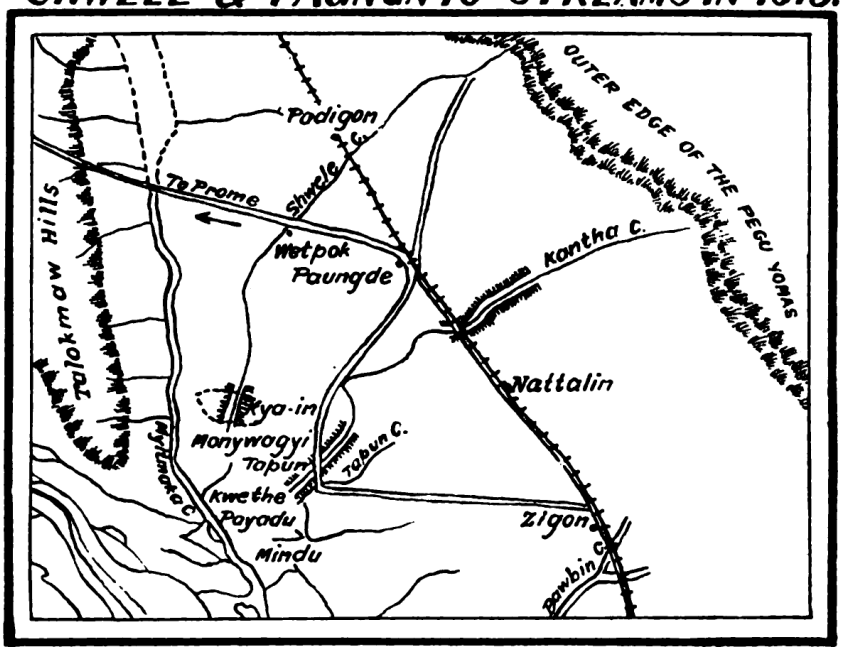
MAP No 3.

SHWELE & TAUNGNYO STREAMS IN 1862.



SHWELE & TAUNGNYO STREAMS IN 1915.



Bund at Railway in 1888; other bunds in 1915 ..

Scale 1" = 8 miles.

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through which it has since formed a good channel for itself. There is clear evidence, however, that this swamp was of comparatively recent origin. In the 1862 map it does not appear at all, but the river is shown as branching very considerably right up to the hills. Gordon in 1879 made no mention of the branch flowing westwards above the railway or of the one flowing due south through Paungde. These channels had vanished altogether. Gordon wrote of the main stream as flowing into the lower end of the Inma swamp. Its subsequent course is easy to follow. Having blocked up the entrance of the swamp, the river sought a new line. Its own deposits on the one side and those of the Taungnyo on the other had in the meantime lowered the relative level of the ground in between; *i.e.*, the *Kya-In* grew in importance. This became the lowest ground in the vicinity, and so the Shwele made for it as soon as difficulties arose in its own channel. How the Shwele dealt with the *Kya-In* is a matter of modern history, to be described later on. The point it is desired to make here is that in the course of half a century the Shwele moved the origin or starting place of its delta downstream from fifteen to twenty miles.

The story is exactly the same with all the other streams, and need not be laboured. It is sometimes possible to trace old channels, but, as a rule, they have disappeared altogether. Perhaps the most striking changes are those that have occurred with the Bawbin, Myole and Gamon streams. The railway is here further from the hills, and so greater changes above the railway were to be expected. This part of the line was constructed (in 1865 to 1868) in what is nowadays spoken of as *laha*. This is clearly brought out in para. 115 of Gordon's Report and in paras. 7 to 9 of Colonel Scott-Moncrieff's note (Chapter X.).

20. Gradual Diminution in the Extent of the Laha.—At the railway all the main hill streams have big bridges and deep beds. Walking down any one of the streams, one cannot help but notice how the banks diminish in height the nearer and nearer one approaches to the *laha*. In the outer zone of the *laha* itself another factor also comes markedly into play. Not only are the banks low because they are still in process of formation by deposition, but the bed itself is subject to rapid silting from time to time. When the current is checked, deposition of silt takes place in the bed itself just as much as on the banks on either side. All the streams except the Thonze and the Bilin become locally so shallow that logs will only float through unaided at the top of big rises. At other times logs and snags stick and by so doing stop rubbish and check the current, thereby accelerating the silting of the bed itself and so making matters worse for the next rise. These shallows are locally known as *thegaws*.

Raising of the banks a few feet may seem very little to talk about, but it makes all the difference to a hill stream such as these. Every inch of deposit means greater carrying capacity of the channel and less flooding. A time comes when floods are the exception and not the rule; then cultivation is practicable; the limit of cultivation is moved further downstream, and the ground thus won ceases to be *laha*.

Three of the rivers—the Bawbin, the Bilin and the Thonze—have already obliterated the *laha* in their vicinity right down to the Myitmaka; the other six streams have not yet done so. The Shwele *laha* is only a mile wide, the

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Taungnyo (Kantha) *laha* is three times as much, and the *laha* common to the Myole, Gamon, Minhla and Mokka streams is fully five miles wide. This is the width of the flooded area on the left bank of the Myitmaka. It takes no account of the larger area between the right bank of the Myitmaka and the Irrawaddy. But even in the case of the Shwele, Taungnyo, Myole, Gamon, Minhla and Mokka streams, it does not mean that their silt is all dropped at the distances given above as the width of the *laha* in their neighbourhood. The Shwele and the Taungnyo are actively engaged in raising the level of their banks right down to the main stream, and they already discharge such large quantities of silt into the Myitmaka that the latter has been forced nearer to the Irrawaddy. This has happened within the past three or four years. In 1915 the possibility of it was foreshadowed, and Mr. Samuelson was so afraid of its effect on the Myitmaka itself that he strongly advised doing everything possible to delay matters. His fears, however, have proved to be groundless. The Myitmaka has been forced nearer the Irrawaddy in at least two places, and good rather than harm has resulted (*vide* Chapter VI.). More land has been reclaimed, and there has been no difficulty in maintaining a through channel for the Myitmaka itself. We may well, therefore, let matters rest until the Irrawaddy is within measurable distance of being reached. How long this will take it is impossible to say with any certainty, but as it is sure to be something like twenty years or more, speculation as to what will then happen is at present of little more than academic interest.

In the case of the Bawbin, the obliteration of the *laha* in its vicinity and the forcing of the Myitmaka westwards took place over fifteen years ago, although the fact was not recognised until 1914. Discovery of the fact that the Myitmaka had transferred itself to what was afterwards called the Mingyi Chaung (*vide* Chapter VI.) and the removal of all obstructions therein eliminated one of the most formidable obstacles to the floating of timber which had previously existed.

21. Effect of the Irrawaddy.—The backing action of the Irrawaddy increases the size of the flooded area, but it must not be forgotten that a good deal of *laha* would still exist if the Irrawaddy were kept out. Until the Myitmaka and its feeders have been able, by the combined action of scouring and silting, to form channels big enough to hold all their waters, flooding is bound to occur. In the interval the more flooding of the *laha*, the better, for the silt fills up swamps and raises the level of the ground sufficiently to make cultivation possible.

The keeping of the Irrawaddy out of the Myitmaka valley has been under discussion for over half a century. Mr. Gordon voted for it in 1875; Lieut.-Colonel Scott-Moncrieff, Chief Engineer, did the same in 1882, but he failed to convince Government of the soundness of the project. After being in abeyance for several years, it was taken up vigorously in 1914 under the name of the Talokmaw-Yandoon Proposed Embankment. It is still under consideration (see also para. 105).

22. Duration and Extent of the Annual Flooding of the Laha.—Although its huge size and the absence of strong currents give the *laha* the appearance of a vast lake, it should not be looked upon as such so much as what it really is, namely, low-lying ground subject to annual and long-continued

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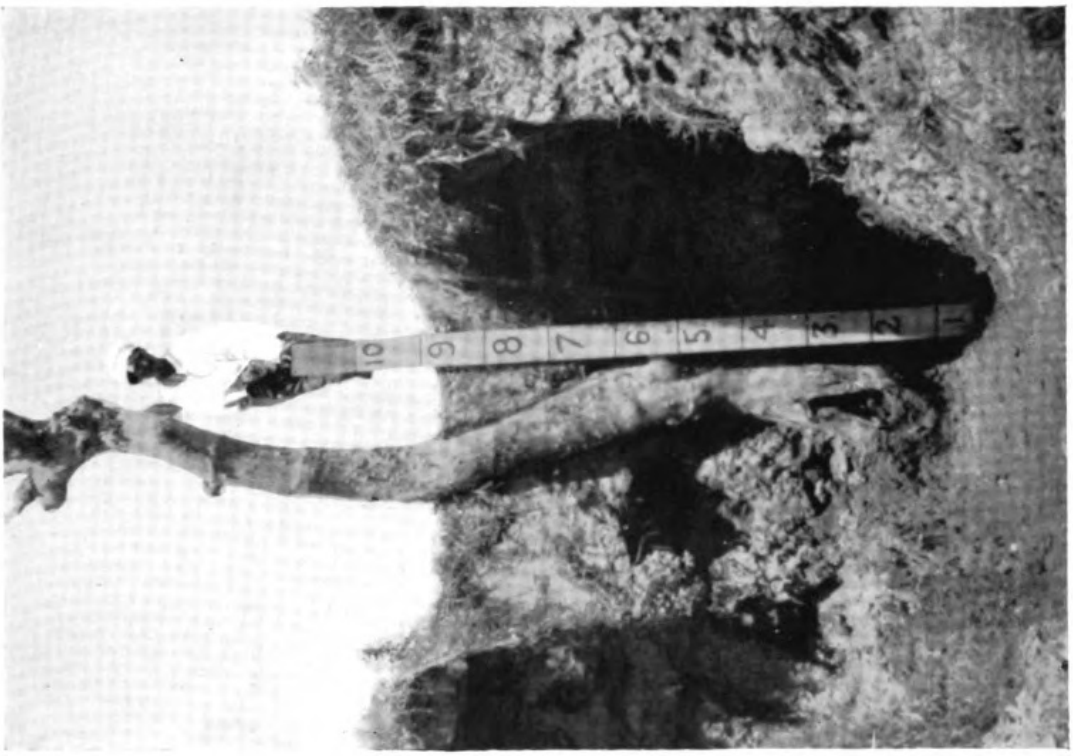

December, 1923. T. MARLOW.

TAUNGNYO STREAM NEAR AYOKMA.

18 and 19. Two views of a tree on the bank excavated down to the roots: the graduated staff shows 9 feet of deposit, adding 1 foot to bed level, total 10 feet.

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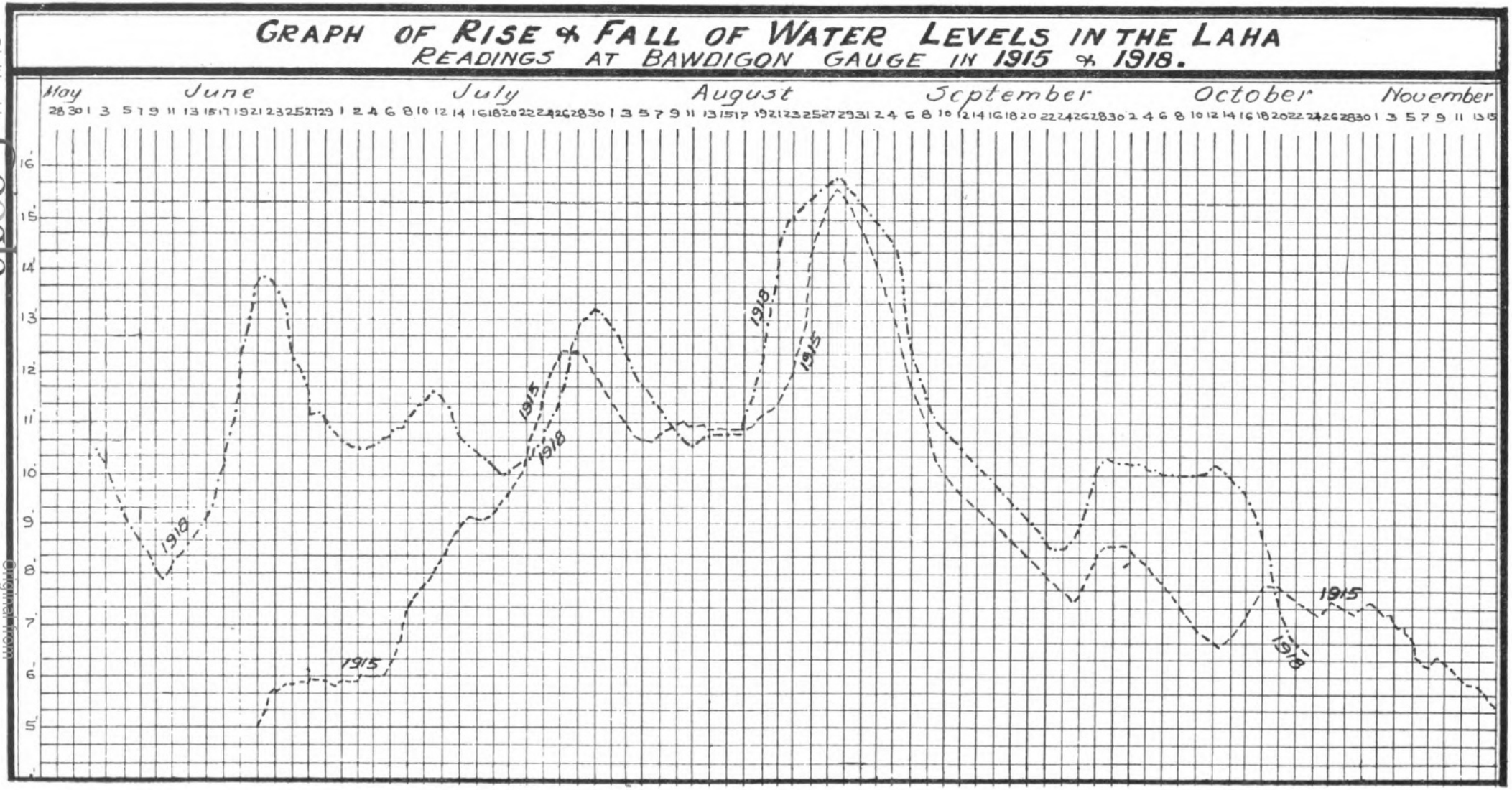

FIG. 3.

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inundation. The backing action of the Irrawaddy being the controlling factor in the situation, it follows that the amount of country flooded depends on the level of the Irrawaddy itself. This varies from year to year, and exceptional rises occur every ten years or so. It is, therefore, the same with the *laha*. Moreover, in any given year periodic variations corresponding to those in the Irrawaddy take place in the level of the *laha*. Figure No. 3 (facing page 21) is a graph showing the rise and fall in the *laha* in 1915 and 1918. The *laha* begins to fill up any time between June 15th and July 15th, and the country remains flooded until some time between September 30th and October 31st. In this period of four to five months, the level of the water is constantly changing. Experience during the past eight years shows that as a rule the *laha* has a marked rise and fall about three times, the difference between the two levels being usually about 5 feet. The slope of the country being about 1 in 2,000 feet, this difference in level represents a width of about two miles. A complete map of the *laha* would, therefore, show it as bounded by two lines anything up to two miles apart, and each of them subject to local variations. These changes in the limits of the *laha* should be carefully borne in mind, because of their effect on the deposition of silt brought down by the hill streams when in flood. In a general description all that can be said is that deposition begins somewhere between the two lines indicated above. The exact locality in the case of a particular flood will depend on the level of the *laha* at the time. If a flood occurs when the *laha* is high, deposition of silt will take place further upstream than when the *laha* is low.

23. Reclamation.—There is no sharp line of division between the *laha* and permanent cultivation. An intermediate zone exists between the two, at one time under water and at another time capable of growing paddy. This being so, the way in which land is reclaimed becomes easy to understand. Reclamation is simply a matter of raising the ground level above the *laha* flood level. Every time a hill stream comes down in flood it brings with it enormous quantities of silt, which begin to drop as soon as the current of the stream is checked on entering the *laha*. When the deposits are sufficiently thick, they begin to show up above flood level, and an addition is thereby made to the land capable of cultivation. The evolution of permanent paddy fields is, however, a gradual one. The cultivator is quite happy provided that his field is semi-liquid mud just above flood level, but considerable additional deposits of silt are necessary before the level of the ground is raised sufficiently high to be safe from inundation.

Photo No. 11 (Plate 6) is very instructive. The picture is of a tree standing about 75 yards from the Minhla stream at the 1923 *thegaw*. The flood mark high up on the trunk shows 12 feet of water when the *laha* was up. Although the ground was under water in September and liquid mud when the writer was there in November, when the photo was taken on January 18th last (1924) the ground had already been hoed up for planting gram.

24. Tree Growth in the Laha.—The whole of the submontane plain, as viewed from the railway, appears to be under paddy cultivation. The landscape is relieved from monotony by tree growth. The tall stems of trees still standing here and there all over the place show that the plain was covered with forest not so very long ago. The Forest Department still looks after a

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number of fairly big blocks of forest outside the hills which were originally reserved for fuel for the railway, besides numerous clumps of teak.

The *laha* country is still under forest with a flora of its own. In 1915 the most noticeable species was the *kyakat* bamboo (*Bambusa arundinacea*), with its formidable thorns. Since then general flowering has taken place and stems have not yet (1924) reached full size.

Near the Myitmaka there is generally dense tree and shrub growth, as shown in Photo No. 20 (Plate 11), taken near the Taungnyo. The Minhla *laha* is much broader, and growth is more open (*vide* Photo No. 21 (Plate 11)). The less deeply flooded parts are covered with a dense growth of *kaing*, or elephant grass ; the presence of *kaing* may, indeed, be taken as a sign that silting is actively in progress, and that very little more is required to make the land fit for cultivation.

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December, 1922. D. A. Ahuja.

20. Dense jungle in the Taungnyo *laha*.

December, 1923. B. D. Lloyd.

21. Open jungle in the Minhla *laha*.

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CHAPTER III

CAUSES OF DETERIORATION OF THE STREAMS

25. In the preceding chapter the way in which the hill streams form their channels by building up their banks has been described without more than a brief reference to the constantly recurring trouble with the rivers which occurred from the earliest times up to within the past eight years. Thanks very much to Mr. Cheyne, the rivers are nowadays absolutely under control. The management of them is so beautifully simple and of such a routine character that new generations of Forest officers and of the public generally may remain quite unaware of what lies behind this ordered outlook. One reason for writing this book is to guard against such a state of affairs. As the story unfolded in later chapters shows, this happened once with deplorable results.

From the earliest times the rivers have been liable to deterioration by breaches of their banks and obstructions. The floating of timber began about 1852, and by its development put a steadily increasing burden on the rivers. All the items are so exceedingly variable that their combined effect varies considerably from year to year. It can readily be understood that there has been room for great diversity of opinion as to the future of the streams. It is unsafe to go by the effects produced in any one season. The right perspective can only be obtained by comparing results in a series of years, and the longer the period the better the inferences are likely to be.

Study of old records is particularly useful in respect to these rivers. About 1910 the idea was general that the streams were getting worse and worse. In 1914 the writer came to the conclusion that they had really been getting better and better for many years past, and that the improvement bade fair to be permanent. Going back some forty years, we find an even worse picture than that drawn about the year 1910. To reconcile these very divergent views at first sight would seem to be an impossibility. The solution of the problem lies in two directions: a closer study of the ordinary causes of deterioration and a realisation of the possibility of special forces being called into play for limited periods. It will be as well to discuss the latter first.

SPECIAL CAUSES OF DETERIORATION

26. Study of old records in 1914 made it quite clear that the history of these plains and rivers was not one of continued evolution under one set of conditions operating steadily and without change for centuries. What conditions were like in the first half of the nineteenth century can only be conjectured; but it is known by the effects produced that in the latter half of the century new forces came into play which upset very much what had happened before. Between 1860 and 1870 the rivers began to deteriorate; that is, the heads of their deltas or cones of deposit began to move upstream. It was not merely a case of the reclamation of the *laha* being arrested, but the limits of the *laha*

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were extended at the expense of cultivation. All through the "seventies" things got worse and worse. When Gordon wrote his Report on the Irrawaddy in 1879 he drew a very gloomy picture. Colonel Scott-Moncrieff's tour of the districts in 1882 was largely due to the existence of the railway being threatened.

Although it took thirty years for it to be realised, yet Gordon was quite right in stating in 1879 that things were "apparently intensifying to a climax." The pendulum did begin to swing back in the normal direction between 1880 and 1885. Flooding became less violent; the heads of the deltas began to move downstream; the channels of the rivers began to improve; shrinkage of the *laha* was once more in evidence.

Long after this period of retrogression was over its effects could be seen in the pessimistic views held, up to ten years ago, with regard to the future of the country affected by the rivers. Opinions were very much divided. Various remedial measures were suggested, but they all came to nothing. Some bunding was done near the railway, but for the rest a do-nothing policy prevailed. The rivers were left to work out their own salvation. They did it remarkably well. So far the policy was justified. The pity of it lies in the cost. Had Colonel Scott-Moncrieff's suggestions in 1882 been adopted and developed even though embankments had been subsequently dropped, the clock would have been moved forward some thirty years; the heavy toll year after year on the produce of paddy fields would have been avoided; the loss of thousands of teak logs would have been saved.

If it is true that there was a definite period in which the rivers deteriorated, then a definite cause must have existed which did not predominate before or after the period in question. Gordon put the deterioration down to the following causes :—

(*a*) Increase in the amount of silt brought down from the hills owing to *taungya* cutting;

(*b*) Raising of flood levels in the Irrawaddy by the Thanbyadaing curve and by the bunding on the right bank.

27. Increase in Silt Deposits.—The Province of Pegu was annexed in 1852. The Pegu Yomas were not brought under protection as forest reserves until 1870. It is quite probable that in the interval there was far more destructive *taungya* cutting than there was either before the former or after the latter date. A good deal still goes on outside the reserves, and in tracts set aside for Karens inside them. The amount of silt brought down nowadays is still very great indeed, but it may be taken for granted that it cannot be materially reduced without very drastic measures. So long, however, as the rivers continue to be as good as they have been for the past nine years, no further action is called for.

If this conclusion is justified, then it does seem a pity that—as remarked in para. 5—Mr. Ellis's proposals in 1909 were so lightly set aside. The then Conservator of Forests, Pegu Circle, stated that he would "not recommend the waste of any Government money on training works until the protection of the catchment area had been fully assured by the prohibition of shifting cultivation." There the matter rested. The waste was really in the logs lost and paddy destroyed by Mr. Ellis's proposals being shelved for five years.

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November, 1914. L. A. TABORDA.

THE MINGYI CHAUNG.

22. The Ngagyi fishery weir, about three miles below Myauklokgon, dismantled in 1916; the normal Rains level of the water was fully 3 feet above the cross poles.

January, 1915. F. A. LEETE.

THE SHWELE STREAM.

23. A fishery weir which existed in the Rains, 1914, and earlier, right across the main channel above Monywagyi, a very formidable obstacle.

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28. Irrawaddy Flood Levels.—About eight miles north of Henzada, at Thanbyadaing, a huge curve began to develop in the Irrawaddy in the earlier half of the nineteenth century. The curve was short-circuited in 1881, thereby shortening the course of the river by about sixteen miles.

Bunding of the right bank of the Irrawaddy was started in 1862, and practically came to an end in 1877; only small additions have been made since then.

The laws governing flood levels in rivers like the Irrawaddy have been the subject of investigation by engineers all over the world for generations. Contributions to the literature on the subject are still being made. All that need be remarked here about the Irrawaddy is that Gordon in 1879 gave first place to the heading-up effect of the Thanbyadaing curve, whilst the more modern theory is that the effect of the curve was far less than that of the embankments. Records do show that there has been a gradual lowering of flood levels since the practical completion of the bunding, and that this fall coincides with the recovery of the hill streams flowing into the Myitmaka.

It may be of interest to note that the Sittang River short-circuited the big loop near Alok in 1909. The length of the main stream was thereby reduced by thirty miles, and flood levels are calculated to have dropped 3 feet.

History is likely to repeat itself on the Sittang in 1924. The head works of the Pegu Canal are at Myitkyo, situated at the middle of a big loop. In the 1908 survey map the width of the neck of the loop measures about a mile. It has steadily diminished in width during the past fifteen years, and is expected to go altogether in the coming flood season (1924). The length of the main stream will thereby be reduced by about ten miles. The effect on flood levels will be instructive.

ORDINARY CAUSES OF DETERIORATION

29. Whilst giving prominence to the special causes of deterioration already discussed, it must not be forgotten that even in the period of their operation they were not the only influences at work. The *régime* of these hill streams with their raised banks has always been one of unstable equilibrium, owing to a number of causes that are more or less always in operation. The special forces hitherto discussed simply upset the balance for the time being. The factors which have always been in operation hitherto and need to be provided for in the future may now be considered.

30. Irrigation Cuts and Branch Channels.—Whenever a stream overflows its banks the reduction in depth and current causes an immediate deposition of sandy silt on the banks. Clay is carried further afield and takes longer to settle. The effect of the flooding is practically confined to a width of about a quarter of a mile. Inside this limit the ground may be raised anything up to 5 or 6 feet in a single year. Beyond this limit the effect hardly exceeds a fraction of an inch annually. The same effect is produced by breaches or diversions, so that it need not be a matter for surprise that in the course of time the rivers have by their wanderings affected ground levels for miles on either side of existing channels.

Held in as these streams are by banks raised anything up to 4 or 5 feet above the paddy fields on either side, it is a simple business to irrigate the

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fields, even if the rivers are not in full flood, by making cuts in the banks. Drawing off of enough water, but not more than enough, to irrigate fields would not have mattered much. The trouble was that the rivers used so often to take advantage of these openings to pour out far more than enough and to shoot out logs as well. A temporary obstruction in the main stream may be quite enough to cause a small irrigation cut to develop into a big breach. The immediate effect of a large volume of water being diverted is to cause the bed of the main stream to silt up. Unless measures are promptly taken to control the flow of water through the breach and to remove the obstructions in the main channel so that it may again scour itself out, the chances are that the diversion will become permanent ; in other words, the stream will have made a new channel for itself.

It is not an uncommon thing to find cart tracks in old maps replaced by streams in later ones. The course of the Shwele below Monywagyi and that of the Mingyi Chaung above Myauklokgon are cases in point, which any one can verify by comparing the streams as they are to-day with the 1882 and 1862 maps respectively. The reason is not far to seek. Cart tracks generally work themselves down to a lower level than the ground on either side. Where they cross the channels of streams, they can have the same effect as irrigation cuts or other openings in diverting the flow of water.

The point which it is desired to make here is that depressions or openings of any sort in the banks of these streams are a source of danger. One of the most effective remedial measures that can be adopted for the control of such streams is to have all depressions filled up from time to time and the banks dressed fairly level.

It is a pity that the fixing of pipes or sluices in bunds and banks was not seriously thought of many years ago. For want of a knowledge of these simple means of reconciling conflicting interests, the Forest Department used to meet with active opposition to bunding proposals.

31. Effect of Field Bunds near Streams.—Although interests conflict to some extent in respect to irrigation, yet there is another matter in which interests are identical. Having got all the water he wants, the owner of a paddy field would rather not have any more. Along all the rivers there are striking evidences that the villagers have done all they can to prevent the flooding of their fields, and their efforts have been largely instrumental in the improvement and control of the streams. By throwing up small bunds along the banks they have increased deposition on the banks and thereby raised them. As Mr. Samuelson once remarked, the cultivators are adepts at the process. The weak point in leaving the business entirely to the villagers was that it was a case of each man for himself, without co-ordination of effort and without sufficient thought with regard to the future. The bunds were not all dressed to a uniform level or slope. They were usually too close to the edge of the stream, as the man on the bank did not wish to give up more of his field than he could help. He sometimes waited too long before retiring to a second line.

The Bawbin is a striking example of the bad effect of having field bunds too close to the edge of the stream. Instead of the river being allowed to spread itself out for a width of several hundred feet, thereby raising the banks

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March, 1914. F. A. LEETE.

OBSTRUCTIONS.

24 and 25. Examples of creeks inside the hills completely blocked by fallen trees and dead bamboos.

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to a corresponding width, deposition was induced close up to the edge of the stream, with the result that the banks in many places have the appearance of artificial embankments. Any opening or depression in such relatively narrow banks is dangerous. It is on this account that the big breach which occurred near the village of Yetho in 1918 gave such a great deal of trouble.

32. Fixed Obstructions and Fishery Weirs.—In the dry season it is a common practice to throw earth dams across the streams near villages to hold up water. There is no objection to these dams, provided that they are cut through before the flood season begins and that all stakes, etc., are removed.

Fishery weirs, on the other hand, are most pernicious on hill torrents. Although the erection of them on the main floating channels of the feeders of the Myitmaka was prohibited many years ago, it was only too plain when the rivers came to be studied in 1914 that the prohibition was practically a dead letter. These obstructions were to be met with everywhere. In the same class were logs purposely fixed across streams at low-water level to serve as foot bridges. On the main Myitmaka there were a number of fishery weirs which were annually licensed and brought in considerable revenue to district funds. As may be seen from Photos Nos. 22 and 23 (Plate 12), these weirs were substantial affairs which interfered very seriously with the free flow of water. A weir of any kind is sufficient to check the current and cause deposition of silt above it. The process is accelerated by the fact that the streams are constantly bringing down large quantities of floating material and refuse generally.

33. Floating Obstructions.—Civil, public works and railway officers were only too ready to ascribe all the trouble with the rivers to the use of them for floating timber. Forest officers in the past were not prepared to admit that their logs caused any obstruction at all. They pointed to the trouble taken by the Department to improve the streams in their higher reaches, and they took credit to themselves for the deepening of the shallows (*thegaws*) by dragging logs across them. It must, however, be frankly admitted that this was a very one-sided view of the matter. It overlooked the fact that jams of logs were not often broken up as soon as they formed, and it ignored the fact that if there had been no logs at all, other impedimenta would not have stuck to anything like the same extent that they did.

The rubbish brought down by the streams was enormous in quantity, probably a dozen times as much in bulk as the logs themselves. Experience at the Wegyi depôt on the Shwele stream between the years 1912 and 1914 may be mentioned. The huge pile of logs, rubbish and silt shown in Photo No. 7 (Plate 4) was a most formidable obstruction, from the injurious effects of which the channel must obviously have taken a considerable time to recover.

The rubbish brought down by the streams was a mixed lot. From 20 to 30 per cent. of it in bulk consisted of short, reed-like lengths of *kaing* grass, bamboos, etc. Then came small stuff of other kinds, such as branch pieces and tops, whole bamboos, etc. Last of all, but most efficacious in causing stoppages, came tree and bamboo roots and whole uprooted trees. All the above were picked up by the streams in their course through the forests. Another by no means small item was household, farm and garden refuse which a stream was sure to receive at every village. The extension of *taungyas*

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(shifting cultivation) in the hills, and of paddy fields in the plains, was responsible for a good deal of the rubbish. It was a common thing for jungle to be cleared right up to the edge of the banks, and for the trees and litter within easy reach to be thrown into the stream.

Photos Nos. 24 and 25 (Plate 13) are illustrations of streams completely blocked with uprooted trees and dead bamboos in 1914. Photos Nos. 26 and 27 (Plate 14), taken ten years later, are of interest as showing that obstructions of this kind are constantly turning up, so that attention to creek clearing should not be allowed to slide, but should be taken in hand every year.

34. There is no use in attempting to deny that the Forest Department was very remiss in the matter of the removal of rubbish in the first ten years of the present century. Next to nothing was done. Everything was left to contractors. This omission is all the more noticeable because teak lessees in other parts of the province set such a good example in the matter. Photos Nos. 28 and 29 (Plate 15) show examples of what the Forest Department set to work to do in 1914. These huge roots which were hauled out of the bed of the old Myitmaka channel at Inwin must have been responsible for a lot of the trouble that arose there.

The Myaung Stream.—As an example of the length of time that some of the obstructions remained untouched, reference is invited to Photos Nos. 30 and 31 (Plate 16), which were taken by the writer on the Myaung stream in 1914. The channel of this stream was so narrow and tortuous that about the year 1910 it was decided to give it up as hopeless for the floating of timber, and to substitute a tramway. When the channel came to be examined in 1914, it was found to be choked with rubbish and obstructions of all kinds. The upper picture shows a teak tree or log (impossible to tell which at the time) which was noticed in December, 1913. This tree was obviously a most effective obstacle to the floating of timber. A tunnel was run into the bank for a distance of 19 feet, and then the roots were struck. The obstacle was, in fact, an uprooted tree. Casting round for evidence as to how long the tree had been in its present position, on the bank immediately above the roots the stump of a girdled teak tree, which was felled in 1912, was noticed. Rings on this stump showed that the age of this tree was not less than seventy years at the time of felling. The inference drawn was that this particular obstruction had been *in situ* for over three-quarters of a century.

35. Water Hyacinth (*Bedabin*).—When the rivers came to be closely studied in 1914, the water hyacinth was so dense above Baudigon as to give serious trouble in the floating of timber. At the time the growth of the weed seemed to be so menacing that danger of the floating operations being altogether stopped was apprehended. When the Mingyi Chaung was first opened, it was decided to try and keep the weed out of it by means of a floating boom at the upper end. Congestion became so great, however, above the boom, that it was decided to open it in 1916. This was done, and a large amount was passed into the Chaung, and a good deal of it found its way downstream.

When the writer returned to Burma in 1919 and made inquiries about the water hyacinth, he was surprised to learn that it no longer gave much trouble on the Myitmaka. Although it grows just as fast as ever, there is no trouble in keeping the main channel of the Myitmaka open. This can be attributed

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January, 1924. B. D. Lloyd.

Obstructions.

26 and 27. Uprooted trees and bamboos in streams ; cases of this kind call for attention every year.

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to the fact that systematic driving operations have been carried out annually since 1916. As much as possible of the water hyacinth upstream of the Kwethe Yo is driven through this channel in the early and late Rains, when the Irrawaddy is low, and there is a good flow from the Myitmaka into it. During high floods the weed is side-tracked into depressions on either side of the Myitmaka throughout its length, and kept there when the floods recede. By the time that the depressions have dried up in the hot weather most of the weed has dried up too, as it cannot stand being long out of water.

As showing that the weed does not give serious trouble, it may be noted that the average annual expenditure during the eight years 1915 to 1922 was Rs. 577 (£38).

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CHAPTER IV

LOGGING OPERATIONS

36. In this chapter attention is directed to the use of the streams for the floating of teak logs. Emphasis is laid on the guiding principles which should be scrupulously followed for keeping expenditure on the floating operations as low as possible, and at the same time giving due consideration to the maintenance of the streams in proper condition for the future. Measures taken for dealing with breaches are intimately connected with the handling of logs, and are, therefore, mentioned here, but more detailed references to them are to be found in Chapter V., where channel obstructions and bank control are discussed.

Need for Attention to Streams if no Logging on them.—Some people may be inclined to think that these streams would give very little trouble, and that it would cost next to nothing to keep them in good order, if there were no logging operations on them, because it is admitted that want of adequate attention to the disposal of logs has been one of the chief causes of trouble in the past. Such an argument would, however, be a very mistaken one. Creek clearing, that is the removal of floating obstructions of all kinds right up to the sources of the streams in the hills, would be just as necessary without logging operations as it is with them. There would be no difference either in quantity or distribution. Moreover, after every care has been taken during the dry season, it always happens that a certain number of troublesome snags, roots and trees come down from time to time in the Rains. Constant patrolling of the streams is essential after every rise, otherwise some formidable obstruction may escape notice and may prove to be quite sufficient to upset a stream altogether. Breaches do occur now and again, especially at the lower ends of the streams, where the building up of the banks is in its early stages. In closing such breaches or in converting them into sluices logs come in very useful. It would cost more to have to manage without them.

37. General Conclusions.—General conclusions applicable to streams of similar character to the Myitmaka and its feeders are as follows :—

(*a*) Prompt and adequate attention to the handling of stranded logs must on no account be allowed to slide. If a logging stream deteriorates or is at all bad the first question to be asked is whether the logging operations are properly conducted or not, and **the standard set in the Myitmaka Division should be insisted upon.**

(*b*) No hard and fast rules need be laid down limiting the number of logs to be launched annually provided that a stream remains in good order. Each river can be dealt with on its own merits.

If, however, a stream is bad, it may be advisable to put a rigid limit to the logging, or to stop it altogether for a time. In the latter case no claim should ordinarily be entertained from the timber firm in question on account of the cost of stopping logs from coming down or for suspending their operations

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April, 1914. L. A. TABORDA.

OBSTRUCTIONS.

28 and 29. Samples of huge teak roots hauled out of the channel at Inwin by the Forest Department skidding machine in 1914.

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altogether. In nine cases out of ten the fault would be found to rest with the firm itself.

38. Proper Control of Logs.—The success of the Training Works in recent years is certainly due more than anything to the unremitting attention given to stranded logs. In previous years next to no attention was paid to the matter. In 1914 the picture was of a series of streams on all of which there were big accumulations of stranded logs.

It cannot be too strongly emphasised that proper attention to stranded logs must continue if the streams are to remain in their present excellent condition. If this part of the logging work is neglected the streams are bound to deteriorate. Past experience has proved conclusively that if logs are tackled promptly the work can be expeditiously done by hand labour. Under old conditions jams of logs were allowed to accumulate, and elephant power was required to break them up. It was the necessity for using elephants which caused so much trouble in the past. Contractors never sent them down to the *thegaws* until they were forced to do so. One of the most striking things about modern methods is the fact that **there is no need whatever for the use of elephants below the railway during the Rains.** None at all have been so used for the past five years. Now and again elephants are still required **in the dry season** for dragging stray logs back to the channel, but this is not often necessary.

Some qualification to the above remarks is required where the streams cross the railway. In spite of the great length of time that has elapsed since the line was built, the fact remains that some of the bridges are unsuitable for streams which are used for the floating of big timber. It is, for example, extremely risky to have a span as small as 20 feet, seeing that logs may be as much as 50 feet long. The bridge over the Myole stream is an example. In 1882 the Chief Engineer, P.W.D., remarked on the inadequacy of this bridge (*vide* Chapter X., page 111). When a bad jam of logs occurs at a bridge elephants are of great assistance in breaking it up. In the Rains just closed (1923) the bridge over the Taungnyo near Nattalin collapsed. A huge jam of some 3,000 logs collected above the bridge and actually forced one of the piers out of position. The bridge consisted of two spans of 60 feet and two spans of 40 feet.

Photo No. 32 (Plate 17) shows an elephant at work at the Nattalin bridge. Photo No. 33 (Plate 17) was actually taken in the Rangoon depôt, but it is a good illustration of the conditions under which elephants used to have to work on the rivers below the railway before the Training Works were started. It hardly needs any comment. The exhausting nature of such work is obvious.

39. General Principles to be followed.—A log that sticks on the sides of a stream as the water subsides will generally be carried on unaided by the next flood. A log which sticks in the bed is bound to be left partly buried and will require assistance. If left alone, the next flood will bury it deeper still. Once completely covered, all trace is lost. If assistance is not given to logs as soon as they begin to stick, they become obstructions holding up other logs behind them. Immense jams (*taiks*) may thus be formed, more or less completely blocking the channel. Silting of the bed immediately begins, the flood level is raised, and the water soon begins to find outlets through low places

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in the banks. Any one of these may become the main channel, and the stream may be permanently diverted.

The number of logs completely buried out of sight during the past half-century must be immense. On places like the old Kyaukwa *thegaw* there must be thousands of them, veritable gold mines in fact.

When a flood goes down, some logs will generally be left stranded on the *thegaw*. It depends on the number and distribution of the logs in the stream when the rise began. If they were in the lower reaches of the river they may all pass over the *thegaw*. If they started further up some of them will be certain to stick. The number may be so large as to completely fill the channel. In such cases prompt measures are essential. **The first step** is to clear a small through channel down the middle of the stream **at once**, so that when the next rise occurs the stream will have no inducement to flow elsewhere. **The next step** is to arrange the logs on either side, herring-bone fashion, so that they may be in the best position for being picked up and carried forward on the next rise.

When a jam has to be broken every drop of water available must be fully utilised, **and at once.** A delay of a few hours may involve heavy expenditure. Every log and every scrap of rubbish must be cleared from the channel, as any obstruction in the bed promotes silting.

Photos Nos. 34 and 35 (Plate 18) were taken on the Taungnyo. They are good illustrations of remarkably good work in herring-boning logs along the banks. It should be particularly noted that all this work was done by coolie labour only ; no elephants were employed. The importance attached to the making of the fullest use of every drop of flood water is obvious.

Some idea of the nature of the difficulties met with in dealing with logs and of the means by which they were overcome may be gained from the following descriptions of our experiences since the Training Works were started.

40. Shwele Stream in 1914.—When the writer first inspected the Shwele early in 1914, a huge accumulation of stranded logs was met with where the stream broke up into a number of channels at Kywedegale, about a mile and a half above Monywagyi. A few of these logs were floated out in 1914, but at the end of the Rains something like 1,500 logs were left in one of the channels of the stream immediately outside the upper end of the embanked canal which was constructed that year. This channel entered the main channel at the lower end of the embankment close to Monywagyi itself. The problem was to work the logs down about a mile of shallow channel, so that they could be passed into the main channel after the Rains had begun. Mr. Bradley, I.F.S., solved the problem very satisfactorily. A small flow of water down the channel in the cold weather made it possible to construct a series of earthen dams. The first one was made immediately below the logs, and the depth of water obtained was sufficient to float them. Having suitably arranged the logs above the dam, the latter was opened, and the logs were immediately carried down to the second dam. The operation was repeated at a third dam, bringing the logs close to the main channel. Later on, after the Rains had commenced, no great difficulty was experienced in passing the logs into the main channel at Monywagyi and thence down to the Myitmaka. One small detail of interest may be mentioned. When the stream came down in flood

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December, 1913. F. A. LEETE.

THE MYAUNG STREAM.

30. Uprooted tree half buried three-quarters of a century ago.

April, 1914. F. A. LEETE.

THE MYAUNG STREAM.

31. The same as the above after a tunnel 19 feet long had been dug to the roots.

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and reached the lower end of the embankments, it caused a reverse current up the old channel and silted it up to some extent. Exactly the same action took place on a small scale as had happened for so many years at the junction of the Bawbin and the Myitmaka near Kyaukwa. These reverse currents are bound to occur when a hill stream comes down in flood and finds the Myitmaka at a low level.

41. Taungnyo Stream in 1915.—The state of affairs at the end of the floating season of 1915 was remarkable. The big embankments constructed before the Rains that year had resulted in a good channel being formed down to the end of the bunds, but the sudden liberation of the full force of the river at this point resulted in it being practically uncontrollable. The old Tapun channel, for a mile or more, was filled up solid with logs, and in addition over 3,000 logs were spread out fanwise all round the ends of the bunds, some of them actually finding their way into Tapun village itself. The problem of handling these logs was solved in a very satisfactory manner. An earthen dam was thrown across the ends of the embankments, temporarily converting the stream into a pond, extending for the full width inside the embankments and upstream for over half a mile. By means of the two skidding machines which were on the spot stranded logs were collected close to the bunds and hauled over them into the pond. They were then arranged in long rows clear of the channel itself. After this had been done the dam was breached and the logs settled down on to the banks. The idea was to pass the logs into the river and float them down to the Myitmaka when conditions were favourable in the Rains. Expectations were fully realised. No trouble was experienced in sending the whole of them down soon after the first floods had occurred.

42. The Bawbin Stream at Inwin.—In the cold weather, 1913–14, the old Myitmaka channel at Inwin (which, for reasons explained in Chapter VI., should rather be called the Bawbin stream) was found packed solid with logs for a length of over a mile. It was thought to be a good plan to haul these logs on to the banks so that the stream might have a chance of clearing itself early in the following Rains, and then to put the logs back again. Skidder No. 1 was used for the purpose. It was expensive, but it did its work satisfactorily. Without it it would have been impossible to have moved a considerable number of the logs, as elephants were not available. Moreover, some of the logs were very large ones.

Although problems such as those just described are not likely to occur again, we have, from time to time, had very serious difficulties to ovecome, which have taxed our resources to the utmost. Examples are given in the following paragraphs.

43. Breaches in the Low Bunds on the Taungnyo in 1917 (by Mr. Cheyne).—As described later on in Chapter VII., low embankments 3 feet in height were constructed on the Taungnyo for a length of a mile in 1916. On August 17th, 1917, the right bank low bund was breached by a record rise bearing 2,000 logs. The breach rapidly enlarged to a width of 60 feet, and some 300 logs were carried out into the fields. To prevent further logs escaping a boom was thrown across the mouth of the breach. This boom did not hold, as the anchor posts were undermined and gave way on a rise on August 30th. The stream below this point was solidly blocked with logs, rubbish and sand.

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A second and double boom was made and teak posts driven in 10 feet deep at 15-feet intervals to ease the strain on the new anchor posts. At the same time the sides of the breach were revetted with bamboo stakes and matting to prevent further widening, as shown in Photo No. 36 (Plate 19). Two double rows of bamboo stakes were driven into the bed of the breach, and well-filled gunny bags were packed between each double row, to prevent further deepening. Two crib spurs were made in the bank immediately upstream of the breach to deflect the flow of water towards a sandbank which was rapidly forming in the stream immediately opposite the breach. A double row of strutted bamboo stakes was made in semicircular form behind the breach (in each case reaching on either side as far as the bunds), thus checking the flow of the water through the breach. This work was completed by September 25th. At a rise on October 26th the booms gave way, but the fences and revetments held, and the breach silted up entirely. The main channel still being completely blocked, the water had to find another outlet. It topped the low bund, with the usual result, the immediate formation of a breach. This new breach was immediately below the one just closed and rapidly scoured to a width of 80 feet. It was at once boomed, revetted and floored, and bamboo fences made across its main flow, as was done in the old breach. No further rise worth mentioning came down in 1917.

44. Taungnyo Stream in 1918 (by Mr. Cheyne).—On May 25th to 27th came an extraordinarily high and prolonged jungle rise simultaneously with an unprecedented and remarkably early flooding of the Irrawaddy. This rise was easily the biggest and longest yet recorded, and the water topped the banks of the stream throughout the last seventeen miles of its course, incidentally breaching the Public Works Department bunds in two places just above the railway bridge.

Over 2,700 logs and enormous quantities of rubbish jammed and filled the whole channel from hut No. 1 to Ayokma, a distance of two miles. All the fences, revetments and booms were carried away, and the whole stream broke through the previous year's breach, carrying away 700 logs. Again began the fight to control the breach and restore the channel. A boom was slung across the mouth of the breach, the posts being strengthened by struts. A second boom of logs was placed outside the bunds. Escaped logs were dragged back before the floods receded and packed in the space between the two booms.

With the object of checking the flow of water through the breach and encouraging silting therein, behind the second boom a strong weir was made, similar to the one shown in Photo No. 38 (Plate 20). Holes 8 feet deep were drilled in the ground with an earth auger at 10-feet intervals, and pointed posts 18 to 20 feet long and 24 inches or thereabouts in girth were driven in with pile-drivers to a further depth of 4 to 5 feet. These posts were kept in position and connected to one another 2 feet from low water level by being bolted to strong horizontal beams, which again were supported from behind by strong struts, one midway between each pair of posts. Between the posts and in front of the beams bamboo stakes were driven into the ground as far as possible and 10 inches apart, and cut off level with the tops of the beams, to which they were lashed with coir ropes. Branches of *kyakat* bamboo (*Bambusa arundinacea*) were packed in front of the weir to act as silt traps. In con-

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September, 1923. B. D. Lloyd.

Rangoon-Prome Railway.

32. The Taungnyo bridge collapsed owing to a jam of 3,000 logs ; elephant at work on the logs.

J. D. Hamilton.

Dragging of Logs.

33. Note the elephant up to his middle in mud, a common sight before the Training Works were started.

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tinuation of the weir, to prevent a channel from forming on either side, low bamboo fences were made. A second row was placed 100 feet back from the weir and strutted where it crossed the main flow. The ends of the bund were revetted with bamboo stakes and mats. Previous efforts having been frustrated by exceptional flood conditions, the works now completed had been made as strong as was calculated to be necessary to stand the pressure of the highest floods with an ample margin of safety.

By the end of July four full bank rises, all bearing large numbers of logs, came down, but the booms, fences, etc., all held, and each successive rise, as well as smaller intermediate ones, helped to silt up the low country behind the breach as well as the breach itself. By the end of the Rains, 1918, the breach was fairly well silted up, but the booms were left in position and the weirs and fences and crib spurs repaired. In the cold weather of 1919–20, the boom logs and posts and weir posts were dug up, the breach by this time having silted up entirely. By the end of 1920 the only indications of a breach at this point were the remains of the crib spurs and boom posts (*vide* Photo No. 37, Plate 19).

45. Breaking up of a Jam of Logs in the Taungnyo in 1918 (by Mr. Cheyne).—On the night of September 9th and 10th, 1918, at about 1 a.m., a full bank rise commenced to carry logs past the Forest Rest House at Zibingwe. It being known that a jam was inevitable, messengers were sent through the night to call all available coolies from all the surrounding villages. At dawn the number of logs arriving was very small, but the water remained high.

As anticipated, a very bad jam had formed. It extended from No. 1 hut to Ayokma, a distance of two miles, just the same as the big jam four months earlier (May) already described. Some 3,000 logs, mixed up with an enormous conglomeration of *débris* of all kinds, including whole trees, bamboo clumps, huge roots, etc., blocked the whole channel (*vide* Photo No. 40, Plate 21), and not a drop of water flowed down it. All the water escaped through numerous side channels which had been scoured through both banks above the jam.

A new channel to the south could easily have been opened from hut No. 1 (Map No. 7, end of book), but the cost of extracting the 4,000 odd logs (1,000 logs from previous rises being still on the *thegaw*) would have been very heavy, and undoubtedly many would have been buried and lost in the silt deposited by subsequent rises. It was therefore decided to endeavour to open up a channel through the logs and rubbish along the old course. By daylight there was still a strong flow of water at the head of the jam, and a little was trickling through the lower end, which had not yet entirely consolidated. As usual, during the formation of the jam, many side channels had opened throughout its length. The object aimed at in breaking a jam is to restore the formerly existing broad deep channel, and to do this a small beginning has to be made, and a channel, no matter how narrow and tortuous, has to be obtained throughout the length of the jam. To do this rubbish, etc., must be removed and some logs rearranged. The rubbish was disposed of by being floated into the side channels, where it was utilised for blocking them and holding the water to the course along which it was desired to form a channel.

Small logs which could be easily handled by coolies with ropes and peavies

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were then hauled either out of the jam or into any available space, and in this way a narrow passage was made through the first 200 yards of the jam. Below this, the stream bed for a distance of 300 yards being entirely silted up, it was necessary to make a small cutting (about 3 feet by 1 foot) to give the water a lead. The process of removing rubbish and rearranging small logs was then continued, and by the evening of the 13th a narrow and tortuous channel had been obtained throughout the entire length of the jam, as shown in Photo No. 41 (Plate 21). A trickle of water was now making its way through the new channel and gradually scouring and enlarging it until a definite flow of water was obtained, thus rendering it possible to dispose of more of the rubbish and small logs by floating the former and hauling the latter down the channel.

More and more room was made available by floating and hauling away small logs until it was possible to deal with the larger logs and to arrange them on either bank in herring-bone fashion (Plate No. 18), with the object of directing the water towards the middle of the channel and encouraging scouring of the deposits brought about by the jam. Logs thus arranged also help to hold the water to the channel by raising the level between the logs on either side of the channel from 15 to 18 inches above the water level outside them.

46. The silt scoured out of this channel was carried to the lower end of the jam, and the small logs floated and hauled out were themselves herring-boned in continuation of the channel. By September 21st a good channel had been obtained, and this continued to improve rapidly. As the bed scoured the groups of logs were widened out, and any small logs which could be floated away were disposed of. Rises on the 26th and 27th brought down in all some 200 logs, once more blocking the channel. It was, however, opened up as quickly as possible. No further logs could be floated out that year, but every effort was made to get the bed of the stream clear. To encourage scouring, a heavy harrow hauled by an elephant was used to stir up the rubbish. By this means enormous quantities of rubbish, snags and bamboo roots (the accumulation of successive jams) were disposed of. By the end of November the channel was in a much better condition than could have been anticipated earlier in the year.

Rains, 1919.—Before the Rains of 1919 a form of small plough was used to scoop out a channel 3 feet wide and 1 foot to 18 inches deep in the sand to give the water a lead down the middle of the channel. The first rise followed the leading channel and rushed like a mill-race down the new cut, owing to the Irrawaddy not yet having overflowed its banks. A very good channel was soon obtained, and all the logs left on the bank and bed were floated out before the end of June, 1919.

47. Log Booms (by Mr. Cheyne).—The foregoing descriptions of the way in which big jams of logs were handled could be multiplied indefinitely from the experiences of officers during the past eight years. The construction of booms to keep logs from going astray through breaches in the banks is one of great practical importance. If a boom gives way under the pressure of logs and a strong current, all the other defences of the breach often go too, and everything has to be started over again.

Booms play a very important part on the Myitmaka itself. With the

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December, 1920. T. MARLOW.

THE TAUNGNYO STREAM.

34 and 35. Two views of logs arranged herring-bone fashion ready for launching in the next rainy season.

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banks of the stream for miles under water when the *laha* is high, there is nothing but the current to hold the logs, as rafting is not practised above Hmetkadan. The current is by no means steady and in one direction all the time. When the *laha* is rising, in many places a current is set up across the Myitmaka from west to east. When the *laha* begins to fall, the direction of the currents is reversed. Booms, therefore, have to be constructed to withstand pressure alternately from both sides.

A study of currents in the Myitmaka is of the greatest importance for officers in control of logs after they enter the Myitmaka from the hill streams. Lack of attention to this detail may result in excessive expenditure on booms, and this is a matter of some moment, because the number of logs used for the purpose runs into several hundreds, even if the greatest care is taken. On the other hand, if booms are not placed where required large numbers of logs may go astray, causing extra expense and trouble in recovery. In such a vast network of swamps and jungle the possibility of logs being lost sight of altogether is by no means inconsiderable. It is to be remembered that boats are a necessity for the local population for the greater part of the year. Dug-outs are therefore very valuable articles, and it would be saying too much of human nature to suggest that they are always lawfully acquired.

48. Effect of the Training Works on Outturn of Logs.—As this book is primarily only concerned with the regulation of the streams, a good many details of the logging operations find no place in it, *i.e.*, fellings, conversion into logs, dragging of the latter to the banks of streams, floating and rafting down the Myitmaka to storage depôts and ultimate despatch to Rangoon and sale there.

The Training Works originated at a time when there was serious alarm at the dwindling outturn of logs from the departmental operations as a whole. One river, the Shwele, was given up in 1911 in favour of transport by rail, and soon afterwards active preparations began to be made for doing the same thing with regard to the Taungnyo. It was thought to be only a question of a few years before the floating of logs to Rangoon except down the Bilin and Thonze streams would cease altogether.

In 1915 the picture changed entirely. From being utterly discredited the rivers again came into favour, and within another two years their position became quite assured. All further thought of substituting rail transport ceased. The following is a summary of outturn of logs on all the streams affected by the Training Works :—

Shwele.—The average annual outturn from the Shwele in the seven years 1907–13 was 1,866 logs. In 1914 999 logs were floated out to Sanywe, and 7,234 logs were stopped at Wegyi ; total, 8,233. In the eight years 1915–22 the average annual outturn was 12,156 logs.

Taungnyo.—The average annual outturn from the Taungnyo from 1907 to 1913 was 2,597 logs. In 1914 the outturn was 4,214 logs. In 1915 the figure jumped to 10,755, and in the following years there was a steady increase, the average for the eight years 1915–22 being 16,205 logs.

Bawbin.—The average annual outturn from the Bawbin in the seven years 1907–13 was 3,443 logs. In 1914 the actuals rose to 4,234 logs, and the average from 1915 to 1922 was 11,689 logs.

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Myole.—On the Myole hardly any logging was done in the years preceding the Training Works. From 1915 to 1922 the average annual outturn was 623 logs.

Gamon.—The average annual outturn from the Gamon from 1907 to 1913 was 1,507 logs. In 1914 the outturn dropped to 625 logs, but it made a good recovery to 3,465 logs in 1915, and the average from 1915 to 1922 inclusive was 5,556 logs.

Minhla.—The average annual outturn from the Minhla stream from 1907 to 1913 was 749 logs. It rose to 1,052 in 1914, and the average from 1915 to 1922 was 3,295 logs.

Mokka.—The average annual outturn from the Mokka stream from 1907 to 1913 was 420 logs. In 1914 it was 1,505 logs, and the average from 1915 to 1922 was 1,116 logs.

Variations in the outturn of any given stream may occur from year to year, but the foregoing figures cover a long period both before and after the Training Works were started. There can be no question as to the increase in outturn which has taken place during the past eight years. From the point of view, therefore, of increase in outturn of logs, the success of the Training Works is unquestionable.

But this is not all. By the railing projects it would have been quite impossible to have handled the large outturns of recent years. The maximum number of logs dealt with at Wegyi in a single year was 7,234 logs in 1914. The officers who had the strenuous task of running the depôt that year will certainly not dispute the statement that the resources of the depôt were taxed to the utmost, and that the subsequent average of 12,000 logs could not have been coped with at the depôt without the remodelling of the mechanical appliances there at considerable additional expense.

49. Limitation of Outturn of Logs.—In the early days of the Training Works the possibility of having to curtail the outturn from individual streams was contemplated. No active steps were, however, taken in this direction. It is quite true that the number of logs stranded in 1914 was very great, and that the Training Works in 1915 would not have been put to such a severe test that year if steps had been taken to hold up logs in the forests ; but this was not done because of the complications likely to result in future years. The number of logs ready for launching in the forests was known to be very large, and it was not thought desirable to delay sending them down owing to the risk of damage by fire. Moreover, it was thought that an undue strain might be put on the capacity of the streams later on if logging itself were not stopped at the same time. As events have proved, however, curtailment of outturn was unnecessary. The rivers responded so generously to the efforts made to improve them that all thought of restricting the outturn, on account of the floating capacity of the streams being limited, was given up. It is interesting to note that during the past eight years the Shwele outturn exceeded 20,000 logs on one occasion, and that from the Taungnyo did so twice. The remarks made in para. 37 should not, however, be overlooked. Even though no hard and fast rule need be laid down as to the number of logs to be put into a stream annually **so long as it is in good order,** if the stream shows any signs of deterioration, the question should at once be raised as to whether

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August, 1917. G. C. CHEYNE.

LARGE OPEN SLUICE.

36. Revetment and flooring of a sluice made in the Taungnyo embankment in 1917.

December, 1922. D. A. AHUJA.

37. Same as above five years later; sluice completely silted up, 10-feet bank formed; nothing left showing but the tops of the boom posts.

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a rigid limit should not be put to the logging, or whether it should be altogether stopped for a time.

50. Loss of Logs.—One of the chief reasons advanced in favour of railing projects such as that at Wegyi was that the loss of logs by floating was very serious, and that this loss would be entirely saved by the railing method of transport to Rangoon. What the actual loss by floating had been no one could say with any certainty, but it was variously estimated at from 5 to 20 per cent., with an average of 10 per cent. From the description given in Chapter III. the possibility of logs getting lost can readily be imagined. Leaving out of account losses by fire and theft, the number of logs completely buried by deposits of silt in the course of the past half-century must have amounted to an enormous total. Places like Kyaukwa on the Bawbin and Monywagyi on the Shwele must be veritable gold mines of logs.

A recent visit to the Minhla stream provided very good ocular evidence of the way in which logs used to get lost on all the streams dealt with in this book. Although the good channel, with its raised banks, comes to an abrupt end in the seventh mile, the channel continues as a shallow one on into the *laha*, the deposits of new silt tailing off to nothing about a mile ahead, except in the bed itself. Several logs were noticed embedded in the banks (*vide* Photos Nos. 44 and 45). All these logs came down during the floating season just closed and will in the ordinary course be dug out and placed ready for floating next season. The point it is desired to bring out is that under old conditions logs such as those illustrated would have stood very little chance of coming out at all. With so little attention given to this part of the logging operations, it is no wonder that estimates of the loss of logs in the past were high. There is also a lesson to be learnt for the future. The close attention now given to the streams must be continued even though they may not give trouble with big jams of logs and the formation of breaches such as are described at length in this book.

51. A careful record is now kept of all logs prepared in the forests and also of logs launched into the streams, and of receipts at various places on the Myitmaka. In addition, complete stock-taking (Burmese *neap*) is done once a year throughout the whole length of the hill streams and the Myitmaka. It is a rather remarkable fact that although every care has been taken over the annual *neap* statements, it was not until 1923 that a deficit balance appeared from the returns. Old logs constantly kept coming to light, disguising the actual losses. What the latter actually are it is, therefore, impossible to state, but **there is every reason to believe that the estimate in 1915 of one log in a hundred is fully double the loss that actually occurs nowadays.**

Although railing projects such as the Wegyi one have been things of the past for several years, they may be revived elsewhere in the future. It may, therefore, serve a useful purpose to give prominence to the fact that the claim made for the Wegyi project that it would eliminate all losses of logs below the railway could not be substantiated. Experience for three years showed that the boom could not be relied upon to stop all logs. Excluding a big batch of logs which escaped downstream by the breaking of the boom on October 8th, 1914, it was proved that **normal escapes** by ducking under the boom amounted to 14 per cent. of the logs which came down from the forests that year. There

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cannot be the slightest doubt that year in, year out, escapes from such a depôt would not be less than 10 per cent. As the river below such a depôt would ordinarily be left very much to itself if the depôt were maintained permanently, only a very small proportion of the 10 per cent. of escapes would stand much chance of reaching Rangoon. An absolute loss of not less than 5 per cent. may be taken as a certainty. This is the lowest limit for purposes of comparison with river transport.

52. Expenditure on Training Works and Logging.—The cost of the big embankments constructed on the Shwele, Taungnyo, Bawbin and Minhla streams in 1915, including payments for acquisition of land, amounted to £7,610 (Rs. 114,160*) spread over 1915 to 1917. The cost of the low bunds made on the Taungnyo in 1916 was £1,539 (Rs. 23,081). The opening of the Mingyi Chaung in 1914 cost £564 (Rs. 8,464). The making of short cuts, digging channels deeper, making leading channels and jungle clearings, in the four years 1915 to 1918, amounted to £1,978 (Rs. 29,656). All the above items were treated as capital expenditure, and also £761 (Rs. 11,419) on the purchase of skidding machine No. 2 in 1915. The total expenditure on capital account was, therefore, £12,452 (Rs. 186,780). Since 1918 all expenditure has been charged to working expenses. None of the individual items have been large, and there was therefore no necessity to classify them separately. Expenditure on logs, as distinguished from that on training works, cannot be separated. It would be impossible to have done so.

The outturn of logs on the seven streams (Shwele to Mokka inclusive) on which any expenditure was incurred on training works was as follows :—

	No. of Logs.
1915 to 1922 (eight years)	405,127

The total expenditure during the same period was as follows :—

	Rs.	
Capital cost of embankments of 1915–16 .	137,241	(£9,149)
Other items on capital account . .	49,539	(£3,303)
Total	186,780	(£12,452)
Working expenses	332,080	(£22,139)
Total capital and working account . .	518,860	(£34,591)

The average cost per log works out at —

On capital account	7 annas or pence
On working account	13 annas or pence
Total	Re. 1 as. 4 per log (1*s.* 8*d.*)

The foregoing figures of expenditure refer only to floating operations down to delivery of logs in depôts on the Myitmaka. They do not include the cost of logging operations in the forests. The cost of rafting to Rangoon is approximately Rs. 2 as. 12 (3*s.* 8*d.*) per log. The total cost for comparison with transport by rail is Rs. 4 (5*s.* 4*d.*) per log.

* Exchange is taken at 1*s.* 4*d.*, *i.e.*, Rs. 15 to the pound.

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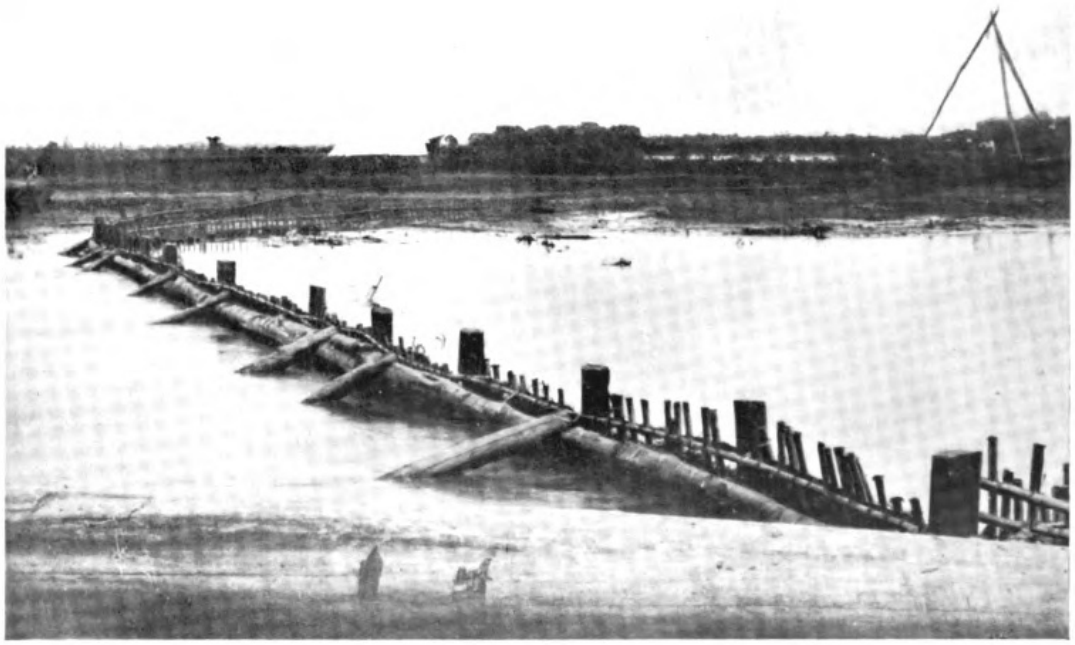
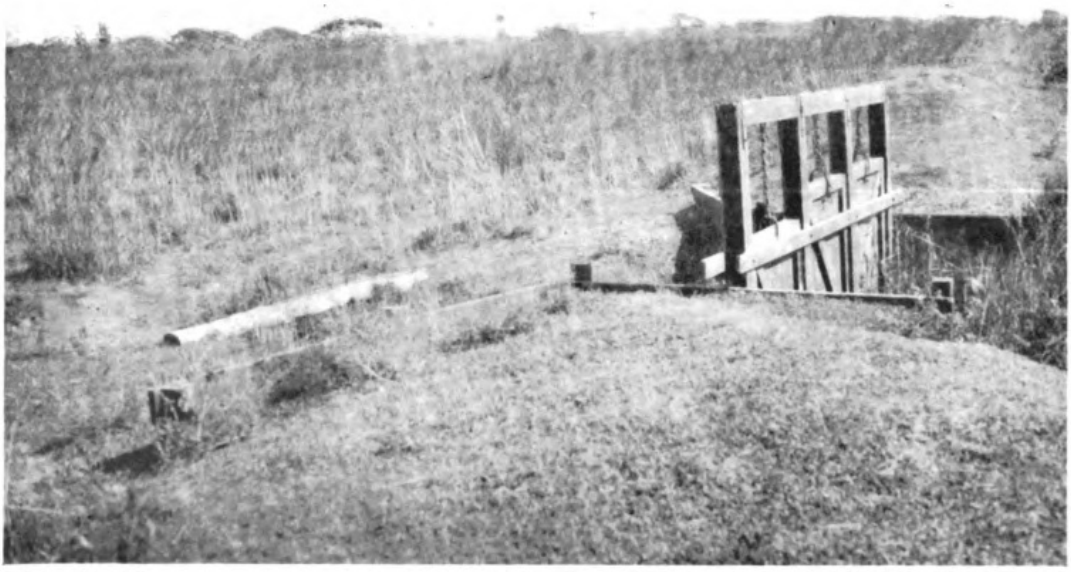


August, 1922. C. R. ROBBINS.

TAUNGNYO STREAM.

38. Strutted weir similar to the one made across the big bridge in the low embankment on the Taungnyo stream in 1918.



December, 1922. T. MARLOW.

TAUNGNYO STREAM.

39. Boxed sluice with sliding traps made in the big embankment on the Taungnyo stream.

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53. Comparison between Cost of Floating and Rail Transport.—Judging from actual results of working the Wegyi depôt in 1911 to 1914, the average cost of stopping logs at any of the railway bridges and railing them to Rangoon would not be less than Rs. 11 (14*s.* 8*d.*) per log. The gain to Government in the Forest Department by continuing to use the streams and training them has, therefore, amounted to Rs. 7 (9*s.* 4*d.*) per log or Rs. 350,000 (£23,333) per annum for a period of eight years on an average outturn of 50,000 logs. This saving will be an annually recurring one so long as the outturn remains the same. The absolute gain has been greater than these figures indicate, because it would have been a physical impossibility to have handled anything like as many as 50,000 logs annually without proportionately higher expenditure on mechanical equipment.

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CHAPTER V

CHANNEL OBSTRUCTIONS AND BANK CONTROL

FLOATING OBSTRUCTIONS

54. Removal of Floating Obstructions.—The bad state of affairs in 1914 has already been referred to in Chapter III. The removal of floating obstructions never had been looked upon as anybody's business except that of the Forest Department. This was a great mistake. To make things worse, local forest officers did not realise the importance of the matter. The removal of such obstructions was left entirely to timber contractors. They did practically nothing at all. It was useless to expect them to do anything more. They would not touch each other's logs, however badly jammed, and it was extremely rare to find them removing snags, roots, uprooted trees, etc. As time went on they took less and less interest in keeping the channels open.

When the writer was on tour in Prome in January, 1915, he came across elephants belonging to the teak lessees which were engaged on creek clearing. The value of the operation was obvious, and naturally led to the question being asked whether the Forest Department paid much attention to the subject in its own departmental timber operations in Tharrawaddy. The answer was so very decidedly in the negative that it was immediately followed by the suggestion to the timber staff that the matter should at once be taken up seriously. As soon as attention was directed to it, the magnitude of the task became apparent. Years of neglect of this simple operation had led to great accumulations. Wholesale flowering of bamboos about that time made matters very much worse, and it is literally true to state that many of the feeders were absolutely choked with obstructions, such as are illustrated in the photos on Plates Nos. 13 and 14.

55. Orders issued in 1915.—The orders issued were to examine all the streams in detail in the dry season and to collect and burn everything that could be so disposed of. Roots and snags which could not be burnt were to be dragged on to the banks. Along all the streams trees overhanging the channel were to be met with here and there. Instead of waiting for them to fall in, instructions were issued to fell them and get them out of the way.

After so many years of neglect, the task was a prodigious one, and could not be carried through in a single season. In the Zigon Division alone the total length of floating streams between the upper floating limit and the railway is about 500 miles. In 1915 a length of about 400 miles was cleared, involving the burning or removal of 17,282 bamboo clumps, 7,518 whole trees, 3,176 stumps, 6,966 snags. The all-round average for all the streams dealt with was a bamboo clump, tree, root or snag every 20 yards, besides small rubbish generally.

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September, 1918. G. C. CHEYNE.

THE TAUNGNYO STREAM.

40. Jam of 3,000 logs above Ayokma.

September, 1918. G. C. CHEYNE.

THE TAUNGNYO STREAM.

41. The same as the above a few days later; note the progress in opening the channel down the middle.

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The expenditure on creek clearing above the railway in 1915 was as follows :—

	Rs.	
Prome	4,330	
Zigon	29,553	
Tharrawaddy	4,247	
Total	38,130	(£2,543)

This large sum did not represent an annually recurring charge, as may be seen from the following figures, which represent the average annual expenditure in more recent years :—

	Rs.	
Prome	750	
Zigon	2,500	
Tharrawaddy	1,750	
Total	5,000	(£333·3)

56. Recovery of Buried Logs.—Apart from its good effect on the rivers lower down, the expenditure on creek clearing in the hills far more than paid for itself in the number of logs brought to light. During the operations in 1915 in the Zigon Division 626 logs were dug out above the railway (expenditure being included above), and many more still remained to come to light in after years ; over a hundred such logs were marked down at the time. The estimated value (on delivery at Rangoon) of the 626 logs was Rs. 26,000 (£1,733), or very little less than the total cost of the creek clearing operations in the Division. In Prome and Tharrawaddy the story was just the same.

It was quite fair to credit the creek clearing operations with the value of the timber recovered, because hardly any of the logs could have come out without first getting rid of the rubbish. Moreover, the chances were that many of the logs would have been destroyed by fire if the creeks had not been cleared. The logs recovered were of all ages. Some of them were almost prehistoric. In several streams axed squares, as illustrated in Photo No. 46 (Plate 24), were recovered. No axing of squares has been done for the past sixty years. A number of buried logs were exposed on the banks of the Bawbin. Photo No. 47 (Plate 24) is a good example ; the logs in the picture were so old that the hammer marks on them were hardly distinguishable.

The effect of the creek clearing on the flow of the streams was remarkable. The amount of rubbish held up on the *thegaws* was decidedly reduced, and this improvement on previous conditions has continued ever since. The task of handling stranded logs is far easier than it used to be owing to the considerably smaller quantities of refuse mixed up with them.

57. Myaung Stream.—Reference has already been made to the Myaung stream in para. 34, and Photos Nos. 30 and 31 (Plate 16) show a fallen teak tree which had been a most effective obstruction for the greater part of a century. The case of this stream may be further considered. The writer inspected the stream for the first time in April, 1914, and even then came to the conclusion that it was not so utterly hopeless for the floating of timber as was supposed. The presence of running water at Ondaw, three miles above

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Tanbingon, in April gave rise to the idea that logs could be worked through a good deal of the most tortuous parts of the stream in the dry season by means of a series of dams. An experiment was started in December, 1914, and continued till the end of March. In the *Indian Forester* for September, 1915, are some excellent photographs and an appreciative article on the experiment by Mr. A. Rodger, I.F.S. It was decided to go through with the dam experiment, although before the season was well advanced the opinion began to be formed that it was superfluous. The more the stream was examined the more it seemed to have suffered from neglect. Between Winthayet and Tanbingon the stream was literally choked with logs, trees and bamboo clumps. Clearing of the whole stream was taken in hand, and obstructions were removed by the hundred. The average was two bamboo clumps, one tree, one stump and two snags every 50 yards. *Kaing* grass was uprooted along the banks.

In addition to the removal of obstructions, the making of short cuts to reduce the tortuous character of the stream was undertaken. Fig. 4 (facing page 45) is a diagrammatic representation of the results obtained in the next two years.

The results of these efforts surpassed all expectations. From being looked upon as absolutely hopeless, the stream now ranks as one of the best in the Division for the floating of timber, and given proper attention, there is no reason why this satisfactory state of affairs should not continue indefinitely.

58. Ngapi-In Stream.—In the diagram of the Myaung stream (Fig. 4) the lower end of a feeder called the Ngapi-In is shown. In 1864 this stream was cleared for a length of ten miles by Lieutenant Seaton, who remarked as follows in the Annual Report for 1863–64 :—

"The results of a partial clearing of the stream were so satisfactory that no doubt can be entertained for its fitness for the floating of timber from the upper forests, which will obviate the necessity there has hitherto been of dragging timber a long distance. It serves also to show that most of the smaller streams in Tharrawaddy can be made available for floating purposes if thoroughly cleared, and if care be taken to watch the timber coming down. In the Ngapi-In stream everything in the shape of jungle, creeper, trees, stumps, and logs was removed from the bed and banks, thus rendering its course throughout free for the passage of elephants and coolies."

What a striking commentary on the state of affairs in more recent times! Fifty years ago the problem was as well understood as it is to-day, and yet by losing touch with the work of these pioneers we have had to learn again by painful experience the lesson their efforts might have taught us long ago. In the interval the ever present jungle strangled and twisted some of the streams to such an extent that some of us were only too ready to believe that they never were fit for the floating of timber. It may be true that some of them are not now fit for the purpose, but it may be taken as beyond question that the remedies known about and used half a century ago can be made just as effective to-day.

59. Taukte Tramway.—What was known as the Taukte Tramway may also be mentioned, as it taught the same lesson. In 1912 the Taukte stream (a feeder of the Minbu stream in the Zigon Division) was voted to be so hopeless, for the same reasons as in the case of the Myaung, that a tramway was built to rail logs for a distance of a little over two miles and then to drop them direct

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January, 1915. F. A. Leete.

The Shwele Stream.

42. Examples of logs more or less completely buried in the banks of the stream above Monywagyi.

February, 1915. J. W. Bradley.

The Shwele Stream.

43. Digging up buried logs in the neighbourhood of Monywagyi.

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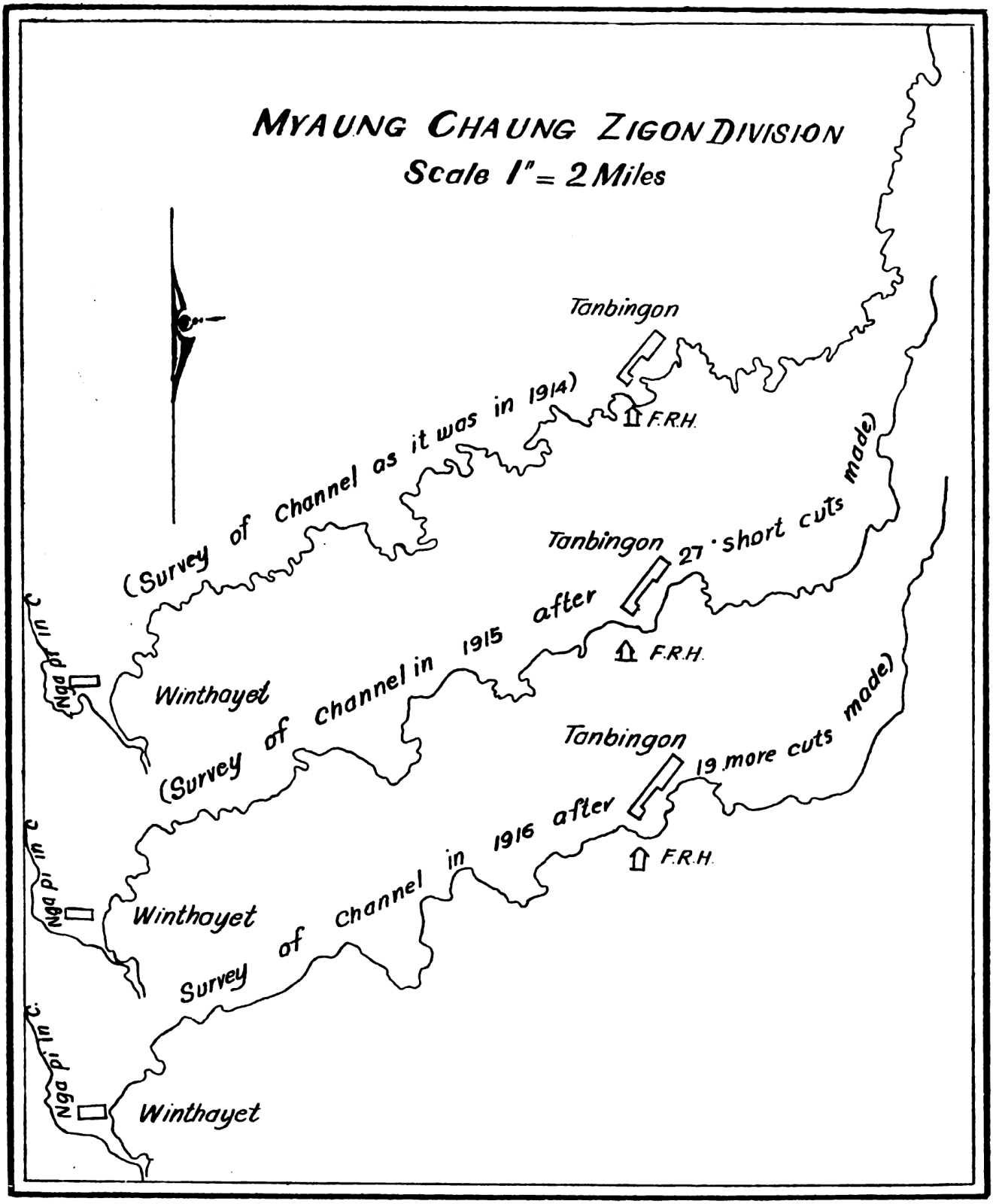
Fig. 4.



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into the Minbu. The project took the whole time of a gazetted officer for two seasons. Most of the logs had been railed before the study of the rivers began. When the stream came to be examined it was found to be no worse than the Myaung. Obstructions were removed, and the stream soon came to rank as a good floating stream. The few logs remaining were eventually floated down at an average cost of no more pence than the tramway logs had cost in pounds.

60. Obstructions in the Myitmaka.—The remarks made about creek clearing in the hill streams are equally applicable to the Myitmaka. The stream bed must be cleared of all obstructions. Overhanging trees and bamboo clumps which are likely to be an impediment to floating, either by falling in and blocking the channel or by holding up logs in their branches during high floods must be removed. The *kyakat* (*Bambusa arundinacea*), the prevailing bamboo in the *laha* area, flowered in 1919, and a considerable expenditure was incurred in 1920 and 1921 in removing and burning all clumps likely to fall into the channel. A few clumps still remain.

A notification was issued in 1917 prohibiting the cutting of any vegetation within 500 feet of either bank of the Mingyi Chaung. Cross-currents, first one way and then the other according to the level of the Irrawaddy, are common. Moreover, banks are low in some places, and are, for the most part, entirely submerged when the *laha* is up. *Kaing* grass is therefore distinctly useful in keeping the main flow of water and the logs borne on it to the channel. Without the grass more booms would be necessary in order to keep logs from going astray. Cultivators are, however, continually encroaching, and prosecutions occur almost every year. More deterrent sentences would appear to be necessary in order to put a stop to such offences.

FIXED OBSTRUCTIONS, FISHERY WEIRS

61. Blasting.—From the earliest times the blasting of rocks interfering with the floating of timber inside the hills has received close attention. The headwaters of most of the streams in Tharrawaddy have thereby been completely changed from what they were in Brandis' time. A certain amount of blasting still remains to be done. Big rocks are constantly coming down, obstructing the channel.

Earth Dams.—As noted in Chapter II., earth dams need not be prohibited, but care should be taken to see that all stakes, etc., are removed before the break of the Rains. These dams are very common on all the streams. Photo No. 48 (Plate 25), taken at Gwegyi, on the Shwele, is typical.

62. Fishery Weirs.—On the representation of the Forest Department, fishery weirs were prohibited in 1916 on all the hill streams and also in the Myitmaka. It was an absolute necessity. Acknowledgments are due to Lieut.-Colonel Nethersole for this measure, as it represented a not inconsiderable loss of fishery revenue for the time.

With a view to increasing the fishery revenue, in 1916 the Myitmaka itself was divided into five stretches, the fishing rights in which were sold by public auction annually by the Deputy Commissioner. Fishing is allowed by nets only; the erection of any fixed obstruction is forbidden in a clause of the

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contracts. The terms of the leases, however, are not being adhered to, and thousands of obstructions are to be found throughout the length of the Myitmaka. The most pernicious of these are consequent on the illegal *chon* method, in which branches are placed in the stream to afford a shelter for fish. Now that many streams are depositing silt in the Myitmaka, the removal of such obstructions every year before the Rains is an absolute necessity.

IRRIGATION CHANNELS AND SLUICES

63. Tapping Streams for Irrigation.—When the Training Works were started in 1915 it was thought to be necessary to prohibit altogether the making of open cuts for irrigation purposes, and to substitute pipes or sluices which could be closed when desired. Later experience, however, has led to some modification of this view. So long as reliance was placed on artificial embankments of relatively narrow width, it was necessary to guard against any deep open cuts being made in them. The construction of big embankments was only done for one year, namely, 1915. After an experiment with low bunds in the following year, the construction of artificial embankments ceased altogether on all these streams. Since 1916 the rivers have been left to build-up their banks for themselves. These natural banks are so wide (a quarter of a mile or so) that, within limits, there is no particular danger in allowing open cuts for irrigation purposes. They should be watched, but they need not be prohibited altogether.

64. Sluices.—The question of sluices is of great importance. In the form of small openings they afford a perfectly safe method of permitting the tapping of the streams for irrigation purposes, and by means of broad sluices reclamation of low-lying ground on either side of the channel can be promoted. The remark applies just as much to the older parts of the streams, with permanent cultivation on both sides, as it does lower down, where the streams are still actively at work on general reclamation. Here and there in the paddy plain low-lying pockets are to be found—the depressions formed when deposition in the neighbourhood originally took place. If it is desired to fill up any such depression, it is a simple matter to make a sluice in the banks of the stream concerned. In the same way, if a breach occurs in the bank of a stream during the flood season, instead of attempting to close the opening at once, it may prove to be preferable to convert it into a sluice. Silt-laden water from subsequent floods can, within limits, be directed wherever desired. When the low ground has been raised sufficiently the sluice can be closed artificially if it does not fill itself up naturally. Examples of the latter are common.

65. The following is Mr. Cheyne's description of his experiences with sluices in the low embankments at Tapun in the Rains, 1916 :—

" The first big flood of the season topped the bunds and breached them in about twenty places. It looked indeed as though they would disappear altogether. Nearly all the openings were promptly closed ; but it was impossible to make any impression on two big ones near the top end of the right bund and the bottom end of the left bund respectively. It was decided not to attempt to do so, for it was clear that they could be made to act as safety

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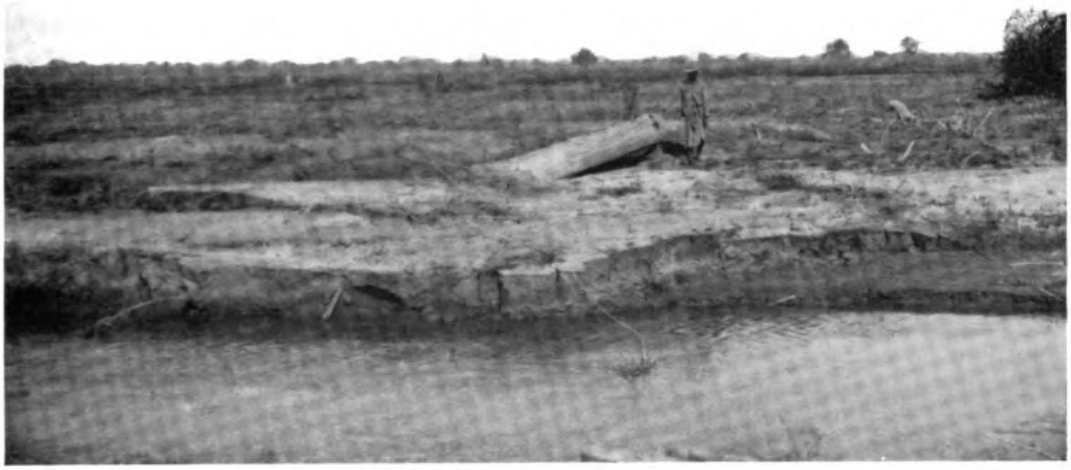

January, 1924. F. A. LEETE.

BURIED LOGS.

44 and 45. Views just below the Minhla *thegaw*, showing channel in *lahɔ* and examples of logs almost entirely buried in the rainy season, 1923.

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valves for reducing the level of subsequent floods. No trouble was taken with regard to the lower breach, as it was so close to the end of the bunds. The upper one (170 feet long) was the important one. There was every reason to fear that the main stream might go off in this direction. A floating boom of logs was at once thrown across the opening of the breach to prevent further escape of logs. Simultaneously the sides of the breach were revetted with stakes and bamboo matting, well packed from behind with sandbags, to prevent the breach from widening, as shown in Photo No. 36 (Plate 19).

"To prevent deepening, the floor was protected by two rows of bamboo stakes driven in as far as they would go (*i.e.*, into the *laha* clay), between which gunny bags filled with sand were tightly packed. This 'safety valve' worked well for several rises, but it was anticipated that it would not be a sufficient outlet when the Irrawaddy rose and its flood waters checked and backed up the Taungnyo water. A similar safety valve was therefore deliberately made, revetted and floored and then closed up, and a boom placed across its mouth. On August 20th it was seen that this additional measure was necessary. A small leading channel was opened, and the sluice was scoured out to the revetments and flooring in a very few minutes, and the level of water between the bunds fell as desired."

66. After the Rains were over and the country had dried up, a striking change was found to have taken place. For a considerable distance round the outside of the sluices, as also on both sides of the stream at the bottom end of the low embankments themselves, huge deposits had taken place. Viewed from outside, it looked as though the bunds themselves had disappeared. An area of no less than 200 acres had been raised sufficiently to become culturable, and was indeed put under paddy the same year.

In the next two years, in addition to the big breaches described in Chapter IV., a number of small ones occurred, none of which appeared to be dangerous, and so no attempt was made to close them. They were allowed to act as sluices, and, in addition, a series of similar small sluices were made. The net result was that by 1921 for the whole length of the low embankments the ground level outside was raised well above the high flood level even with a very high *laha*. Not only was a broad, deep and permanent floating channel obtained, but over a thousand acres of land were rendered culturable and practically secure from danger of flooding.

It is no exaggeration to say that thousands of tons of silt passed into the low ground through these sluices. Samples of silt-laden water taken from the Taungnyo stream at varying times and under varying flood conditions have been found to contain up to 4½ per cent. by volume of silt. An average rise of, say, 8 feet on the Taungnyo is therefore calculated to carry over 20,000 tons of silt past the Forest Rest House at Zibingwe in an hour.

67. Economic Value of Irrigation Channels and Sluices.—It is very satisfactory to be able to state that people can tap the streams where the banks are good as much as they like for irrigation purposes, provided that they do it in moderation. Cultivators do want water from time to time for their crops. To form some idea of how many such openings in the banks actually exist, a count was made on two streams in January, 1924. In a length of thirteen miles of the Shwele from Wetpok to the Myitmaka at Payadu, there were 295 openings. In a length of sixteen miles of the Taungnyo from the railway to the Myitmaka at Ngapigo, there were 238. Sluices opened by the Forest Department were included in the enumeration. The openings varied in size from

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small cuts not more than a square foot in section to big things like the sluice at Gegyi, on the Shwele, with a section of 20 × 4 feet = 80 square feet.

Mr. Cheyne recently informed the writer that he was constantly receiving requests from villagers to be allowed to tap the streams either to fill up depressions or for irrigation ; he cannot find the time to attend to all the applications, as personal inquiry on the spot is generally advisable. The point it is desired to emphasise is that there is plenty of room for the permanent appointment of a civil officer to share with the forest officers in the management of the streams. The maximum benefit to cultivation will not be obtained without some such arrangement. Villagers can only be expected to plan and make short cuts for themselves. To fill up low ground surrounded by cultivation and at a distance from a stream would mean the acquisition of a strip of land for a canal. Levelling would also be called for to ensure getting the right gradient.

68. Masonry-lined Channels Unnecessary.—Engineers may look askance at a system of earthen sluices or canals, but in the case under discussion there is absolutely no need for anything in the way of masonry or brickwork. Under management by the Forest Department such as exists to-day, there is no fear whatever of too much water being tapped either at any given point or in total for a whole stream. In the case of the Shwele and the Taungnyo, with good channels all the way down, the sectional area at the Myitmaka is only about one-sixth of what it is at the railway. Something like five-sixths of the flood water is therefore lost on the way down. Probably not more than a fifth of it goes in irrigation cuts ; the greater part goes by sluices and general overtopping of the banks in the last two or three miles of the stream's course. This is all to the good of the countryside. The Forest Department has quite enough water to float its logs through, and can therefore do very well without the other five-sixths.

Tapping of the streams for either purpose is only a temporary possibility. It must not be overlooked that the streams are actively engaged in building up their banks and in filling up the adjoining parts of the *laha*. Canals such as have been described can only function so long as the streams have raised banks, that is, only so long as they are actively engaged in building up banks and thereby forming permanent channels for themselves. In the older parts of the streams, as, for example, above the railway and to some distance below it, equilibrium has already been reached. There is practically no slope away from the banks ; the ground is, to all intents and purposes, level across the line of the flow of streams. Irrigation is therefore only possible to such a very limited extent that it need not be taken into account. In this part of their course the streams do perform the normal function of rivers in collecting some of the drainage of the adjoining country. It is simply a question of time for the same thing to happen all the way down.

It is not desired to ignore the fact that whenever streams of this character lose any of their flood water there is a tendency for them to silt up their beds. There is constant ebb and flow. Silt dropped in the latter part of one rise is picked up at the beginning of the next one. So long as this continues no harm can result. Sectional measurements of the channels are taken from time to time, so that there need be no fear of deposition in a bed exceeding subsequent

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December, 1915. B. P. KELLY.

ANCIENT AXED TEAK SQUARE.

46. Buried by deposits for fifty years or more, brought to light by the scouring of the Bawbin Channel in 1915.

December, 1915. B. P. KELLY.

ANCIENT TEAK LOGS.

47. Buried for many years, as indicated by hammer marks being nearly obliterated, brought to light by the scouring of the Bawbin Channel in 1915.

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scouring for any length of time without being noticed. Moreover, so long as the streams are used for the floating of timber the Forest Department will be actively interested in seeing that the channels remain good enough for floating purposes. All that needs to be watched is the cumulative effect of small changes continued for a long term of years. This can be provided for by keeping a careful record of special observations at selected places.

BANK CONTROL

69. Care of Banks.—One subject to be kept steadily in view is the avoidance of locally strong currents when a stream tops its banks. Even flow over a long length of bank should be aimed at, so that deposition may be as uniform as possible. The banks of all the streams should therefore be examined every year in the dry season. The advisability of revetting low places which cannot be filled up should be considered. During the Rains, when breaches occur, if they cannot be easily blocked, they should be treated as sluices.

70. Field Bunds.—The harmful effect of having field bunds close to the edge of the channel can be seen locally on nearly all the streams. The Bawbin is particularly bad. The older part of the channel is by no means straight, and on outside curves the high marginal bank is often in danger of being eaten right through. In some places there is a drop of 8 to 10 feet in as many yards. Breaches are, therefore, distinctly dangerous. It may be necessary to acquire a strip of land along the banks to allow of the removal of field bunds that are too close in.

On the newer sections of the streams trouble of this kind does not arise at present. People respect the executive order that no field bunds may be thrown up within 200 feet of the channel, although the planting of paddy closer in without bunds is permitted.

The question of landholders' or occupancy rights in reclaimed land hardly comes within the scope of this book. It is mentioned, however, because it badly needs attention, and it is to be hoped that the matter will be taken up in the proper quarter.

STRAIGHTENING OF CHANNELS

71. Cribwork Spurs.—A certain amount of useful work can be done from time to time in checking excessive curvature of the channels. This is particularly the case in places, such as those just mentioned, where the banks are unnaturally high and narrow owing to the existence of field bunds close to the channel.

It need not necessarily be taken for granted that a bend in one place cannot be eliminated without producing another one lower down. A close study of the Myaung stream (para. 57) brought out a truth of general application, namely, **streams flowing through forest in the plains are bound to be more crooked than out in the open.** After the tree growth has disappeared its previous existence may be overlooked.

72. Removal of Tree Growth and Kaing Grass.—Later on, in Chapter VII., Mr. Cheyne's method of doing everything possible to develop a good channel in the *laha* is described. The remarks here made chiefly refer to the

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central and upper portions of the channels where well-defined banks have already been formed.

It is advisable to cut *kaing* grass along the banks of the hill streams and to repeat the operation annually. The presence of *kaing* grass prevents even flow, and it also causes the banks to encroach on the channel, thereby making the latter narrower and more tortuous. It may be mentioned that the cutting of *kaing* grass had a markedly good effect on the Myaung stream in 1915. The Myitmaka is an exception to the above rule (*vide* para. 60).

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January, 1924. F. A. LEETE.

SHWELE STREAM.

48. Earth dam at Gwegyo for holding up water in the dry season.

December, 1920. T. MARLOW.

BAWBIN STREAM.

49. A more substantial form of fence used for closing the breach at Yetho on the above stream.

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CHAPTER VI

REGULATION OF THE MAIN STREAM (MYITMAKA)

73. The Myitmaka takes its rise in the Inma lake far away from the hills and therefore brings down no silt of its own with which to affect its channel. Until comparatively recent times none of the feeders of the Myitmaka discharged any of their silt into the main river itself. They dropped it all on the way in the *laha*. In course of time, as already remarked in para. 20, the width of the *laha* in the immediate vicinity of the streams gradually diminished, and the streams began one after another to discharge their silt into the Myitmaka in great volume. The effect on the Myitmaka has been remarkable, and calls for detailed discussion.

The first stream to be considered is the Bawbin, which obliterated its *laha*, blocked up the Myitmaka and forced the latter to seek a new channel for itself fifteen years ago. This fact seems never to have struck anybody until early in 1914. For want of it, the efforts previously made to overcome the obstacles to the floating of timber in the neighbourhood were of little value. Starting off with it, a remarkably successful solution of permanent value was arrived at.

74. Opening of the Mingyi Chaung.—The 1882 maps show the Myitmaka as flowing *viâ* Baudigon, Kyaukwa, Shabyugon, Inwin, Ywthaya and Bithalun. At Baudigon the river is some 200 yards wide and fully 30 feet deep in the Rains. At Kyaukwa for several years prior to 1914 there was a very pronounced *thegaw* (FA on Map No. 6, at end of book). Lower down, at Inwin, there was another similar one (HK). When the writer examined these channels in February, 1914, neither of them was more than 30 feet wide or 3 feet deep for a length of nearly a mile. Putting two and two together, the thought occurred that the real Myitmaka must be elsewhere. Local inquiries elucidated the fact that in the large swamps further to the west strong currents were set up in the Rains, and that the currents all gravitated towards the depression known as the Migyaungdin Yo (afterwards renamed the Mingyi Chaung).* Inspection of the locality was difficult owing to the dense jungle growth with which it was covered. At the top end (Baudigon) there was a well-marked and broad but shallow entrance. At intervals all the way down there were indications of a similar character. The removal of all jungle growth for a width of 100 feet from Baudigon to Bithalun, a distance of eleven miles, was put in hand, and was practically finished before the Rains began in 1914, at a cost of Rs. 8,464 (£564). Inspection while the clearing was in progress confirmed first impressions. The clearing showed every sign of being the lowest ground in the vicinity. It looked like a broad and shallow watercourse, with low banks about 200 feet apart. Here and there the banks were hardly noticeable where the track lay across a big swamp. South of Myauklokgon the banks were more conspicuous. Near the lower end at Tanbingon the depression broadened out into a large lake

* *Chaung* = Burmese, stream.

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holding water even in the dry season. At Bithalun the clearing looked very little smaller than the old bed of the Myitmaka, which measured about 100 by 12 feet.

The testimony of officers who saw the clearing in the Rains (1914) as well as the ease with which logs were floated down it that year convinced everybody that more was not claimed for the project than it deserved. The clearing did deserve to be called a river. Photo No. 50 (Plate 26) does no more than justice to it. The volume of water was great, and the current was strong. The channel was not perfect. The upper part was inclined to be shallow, and in the lower part there were some bad bends, which were rather troublesome for rafting owing to the strong current. In 1915 a sum of Rs. 1,530 (£102) was spent on deepening the channel near Kaingdawgyin, about half a mile below the Baudigon entrance, and in 1922 the sharp bend at Ngagyi was eliminated by a short cut.

75. Origin of the Bawbin Cut.—Reverting to the state of affairs in 1909–10, it was unquestionable that the silt of which the Kyaukwa *thegaw* was composed must have been brought down by the Bawbin, as the Myitmaka water carries no silt at this stage. The fact that the *thegaw* extended on the upstream side of the Bawbin junction proved that when the Bawbin came down in high flood it not only checked the current of the Myitmaka, but it actually reversed it. Proof of this statement was easily forthcoming, because Bawbin logs very frequently found their way upstream towards Baudigon.

In 1909 Mr. Ellis started the theory that the reason for the reverse current at Kyaukwa was because of the right-angled junction. In the map, three connections between the Bawbin and the Myitmaka near Kyaukwa are shown. The upper and curved one is the line that the Bawbin is known to have silted up and deserted over twenty years ago. The middle one is the channel complained of by Mr. Ellis. The lower one (LA) is the bunded canal, known as the Bawbin Cut, which was made in 1910–12 at a cost of Rs. 14,346 (£956), with the idea that the acute-angled junction would enable the Bawbin to shoot straight on downstream and draw the Myitmaka after it.

The whole thing was wrong. It was a deplorable example of the futility of attempting to do anything with these streams without first of all getting at the bottom of the causes underlying their behaviour. All that the Bawbin Cut actually did was to make the Kyaukwa *thegaw* a quarter of a mile longer and more pronounced than it was before. The channel was practically wiped out of existence altogether. The remark was made in 1915 that local officers were responsible for the deterioration of the Bawbin stream lower down, because they did not dig out the Kyaukwa *thegaw* in 1914. This was altogether erroneous. To have dug out the *thegaw* would have been an utter waste of money. Nothing but the permanent installation of a powerful steam dredger would ever have kept the channel open.

In the mistaken belief that the map channel was the real Myitmaka below Kyaukwa, until 1914 the efforts of Shwele and Taungnyo timber contractors were entirely confined to getting their logs across the Kyaukwa *thegaw*. This formidable obstacle stood, therefore, in the way of all logs coming down the Myitmaka from the Shwele and Taungnyo forests. Thousands of logs are believed to have been buried in the *thegaw*, and the expense incurred on such

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September, 1914. L. A. TABORDA.

THE MINGYI CHAUNG.

50. The general appearance of the stream from July to October; water 10 to 15 feet deep; densely overgrown with bamboos and other jungle until cleared for a width of 100 feet in 1914.

December, 1923. T. MARLOW.

MEETING OF THREE STREAMS.

51. The Shwele flows in from the left, the Taungnyo from the top right; and the Myitmaka flows towards the right bottom corner. Although big deposits have taken place, and the actual channel of the Myitmaka is now further to the west than it used to be, it is noteworthy that a good channel is still maintained.

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as were dragged through was great. It can readily be understood, therefore, that the whole face of the problem of floating logs down the Myitmaka was changed by the opening of the Mingyi Chaung in 1914. Officers had previously been deterred from attempting any improvement of the Shwele and Taungnyo streams further up by the knowledge that, even if logs were passed into the Myitmaka, they would still have to face the formidable Kyaukwa *thegaw*. With clear water down the Mingyi Chaung, the cost of floating logs from Baudigon to Bithalun was trifling. The saving on logs passed through in one year was sufficient to pay for the whole capital cost of clearing the channel.

76. Training Works in 1914.—The Bawbin itself remains to be considered. The Bawbin Cut developed into a good channel, and from the time that it was in operation in 1912 efforts were concentrated on sending Bawbin logs from the lower end of the cut down the old Myitmaka channel *viâ* Inwin. The village of Inwin is about three miles below Kyaukwa. For some years previous to 1914 the channel here had been steadily deteriorating. Various causes were assigned, namely, the crookedness of the channel, the jamming of logs and the accumulation of snags and rubbish. These factors did all contribute, but the real reason for the trouble was that this part of the river was no longer right in the *laha*. It was at an intermediate stage. The fact that the channel used to be better than it was in 1914 and that the *thegaw* was then of comparatively recent growth need not have been perplexing. The Bawbin had not only diverted the Myitmaka, but it had lengthened itself for about ten miles by appropriating the old course of the Myitmaka as far as Bithalun. A thorough grasp of the fact that the Bawbin then had an extra ten miles of channel **more or less in the laha** may help to make matters clear. The diversion of the Myitmaka was gradual, and there was nothing to cause rapid silting at Inwin until the *thegaw* at Kyaukwa had become fully established. Then in the ordinary course silting of the channel in Inwin began in earnest. The Bawbin Cut of 1910–11 undoubtedly accelerated the deposition of silt in this direction in exactly the same way that the bunding of the Taungnyo at Tapun upset the *régime* of the Tapun stream below the junction. In 1909 conditions were already bad at Inwin, according to Mr. Ellis. In 1913 the channel had shrunk for over a mile to about 30 by 3 feet. In 1914 it was thought that the giving of a free run to the river by the removal of logs and snags in the dry season and the breaking up of jams of logs as soon as they formed in the Rains would enable the river to improve its channel. These expectations were not realised. At the end of 1914 the channel was smaller in width than it was before, and the outlook was far from promising. It then became clear that until the river had raised the ground level considerably it stood no chance of forming a deep and broad channel for itself. This would take several years; moreover, the *thegaw* would not disappear; it would simply travel downstream till it reached the Myitmaka at Bithalun. Then the Kyaukwa story would begin over again.

77. Training Works in 1915.—The problem before local forest officers in 1915 was a twofold one. The first thing to be thought of was the reduction of expense on logs whilst the Bawbin was in this unstable state. Bunding naturally suggested itself, and the logical sequence to this was the leading of the Bawbin by the shortest route into the deeper part of the *laha*. The Inwin

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channel was tortuous, and skirted the *laha*. The shrinkage of the channel in that direction having been due to deposition, the ground level there was higher than it was further in the *laha* towards Myauklokgon. This view was confirmed by the fact that the bulk of the Bawbin flood water made its way in the latter direction. As the map shows, there are large swamp areas between the end of the Bawbin Cut (A in Map No. 6) and the Mingyi Chaung. It was believed that once logs were passed into this low ground (Kywegaung-In) they could be poled into the Mingyi Chaung without much trouble. In order to lead the logs to this low ground, a canal flanked by big double embankments from the end of the Bawbin Cut down to Shabyugon village was constructed in 1915, on Mr. Samuelson's advice, at a cost of Rs.38,538 (£2,569). At the same time the bunds of the old Bawbin Cut were raised and dressed at a cost of Rs.2,329 (£155).

78. The Alè Myaung.—It may be noticed from the map that the channel selected for passing the logs from the lower end of the new embankments into the Mingyi Chaung does not run straight into the latter, but turns off at right angles until close to Myauklokgon. This channel came to be known as the Alè Myaung. The object in view in making this diversion was to prevent Bawbin flood water from passing direct into the Mingyi Chaung. Mr. Samuelson held the opinion that efforts ought to be made to delay direct connection between the Bawbin and the Mingyi Chaung as long as possible, because he thought that such connection would be bound to cause silting in the Mingyi Chaung itself.

The North Myaung.—At the end of the Rains, 1915, the Alè Myaung was inspected by Mr. Samuelson and the writer, and because traces of Bawbin silt were found in the Mingyi Chaung at Myauklokgon, Mr. Samuelson strongly advised obstructing the entrance there and leading the Bawbin water further on into the Yongyaung swamp. This was not done, however. The Alè Myaung itself caused some trouble because it began to silt up and a number of logs were left stranded in it. It was also noticed that the greater part of the Kywegyaung swamp had been filled up, and that the strong current of the Bawbin showed a tendency to head direct to the Mingyi Chaung, near the lower end of what had been the Kywegyaung swamp. Local forest officers were of opinion that it would be a good plan to let the whole of the Bawbin water take this route. The current was likely to be so strong that the Bawbin silt would be carried a long distance down the Mingyi Chaung, and so the fear of the latter being blocked up at the entrance did not seem to be a serious one. The writer came to the same conclusion, and a clearing was made accordingly direct to the Mingyi Chaung. It was afterwards known as the North Myaung.

This measure fulfilled all the expectations of local officers. At the beginning of the Rains, 1916, the Bawbin floods kept to the Alè Myaung, but in August logs began to stick badly, and the channel began to silt up. The river then took to the North Myaung, and a very strong current soon developed down it, and it did not take long for the stream to scour out a broad and deep channel for itself. From then onwards the Bawbin showed no inclination to take any other line, and no further trouble with logs was experienced.

79. Mingyi Chaung in 1923.—Seven years have elapsed, and the fact that the Mingyi Chaung below the North Myaung junction is still as good as

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September, 1916. G. C. CHEYNE.

THE TAUNGNYO STREAM.

52 and 53. Views below Omyedwin after a rise bringing logs; note the logs strung out on both sides of the channel, the latter only about 20 by 3 feet.

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ever may well be taken to prove that the fears entertained with regard to the opening of the North Myaung in 1916 were groundless. Immense quantities of Bawbin silt have been, and continue to be, discharged into the Mingyi Chaung and all over the low ground on both sides of it. The banks of the *chaung* have been raised, and a well-defined channel nine miles long, and of an average width of 160 feet and of an average depth of 10 feet, has been secured. The Mingyi Chaung has, therefore, in reality been improved by the discharge of Bawbin silt into it. From the fact that the general direction of the *laha* current in the neighbourhood of the Mingyi Chaung is from west to east, the deposit of silt on the east bank is noticeably greater than on the west one.

80. What actually happens in an average year is described by Mr. Cheyne as follows :—

" When the Irrawaddy is low and the Bawbin stream comes down in flood, all the silt is discharged direct into the Mingyi Chaung. Large quantities of silt-bearing water flow through various channels into the Ingwetgyi-In, which is filling up rapidly. Some silt is carried into the Yongyaung swamp through a channel below Myauklokgon known as the Kyaung Yo, but the greater part is carried into the Tanbingon lakes, which are rapidly being obliterated. A small quantity is carried upstream and forms a *thegaw* in the Mingyi Chaung above the Bawbin junction. This *thegaw* is quickly removed when the flow from Baudigon down the Mingyi Chaung commences, *i.e.*, when the *laha* water begins to rise.

" When the Irrawaddy is high and the general direction of the *laha* current is from west to east right across the Mingyi Chaung, no silt reaches the Ingwetgyi swamp, none reaches the Tanbingon lakes, but all of it is deposited in Yongyaung and Ngashinaing swamps, with the result that these depressions are rapidly silting up, and a marked extension of cultivation is taking place."

The longitudinal section of the Mingyi Chaung reproduced in Fig. 6 (facing page 67) was taken at the end of 1921, and shows that in a distance of nine miles from the Bawbin junction to Bithalun there is a fairly uniform slope and a total fall of 16·6 feet, or an average of nearly 2 feet per mile.

81. Future Diversion of the Mingyi Chaung.—Good as the Mingyi Chaung is to-day and may remain for some years longer, there is no wish to deny that it may eventually share the same fate as the old Kyaukwa-Inwin channel and become silted up. Such an event need not, however, be feared at all. It would indeed be absurd to think of it as being in the nature of a calamity. If and when trouble begins at the Bawbin junction a new channel for the Mingyi can be made at very little expense into the Ingwetgyi swamp, and the lower part of the present Mingyi Chaung down to Ngagyi can be appropriated by the Bawbin.

Looking still further ahead, it may be found possible to improve the Myitmaka by eliminating the series of loops above Baudigon. Whenever desired a good line for the main river can be found in the chain of swamps shown in Map No. 6. Each such change means further reclamation, which may be looked upon with satisfaction, until the whole of the low ground east of the Irrawaddy has been filled up.

82. Diversion of the Myitmaka by the Shwele.—Forcing of the Myitmaka to change its course is not confined to the Bawbin stream. Fifty years ago the Shwele joined the Myitmaka several miles further up than in recent

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years. After blocking up the Myitmaka the Shwele took an entirely different line and made for the Kya-In swamp. This happened between 1865 and 1875. The Myitmaka then righted itself, and for nearly half a century it received no silt from the Shwele, Taungnyo, or any other streams above the Bawbin. This was the state of affairs when the modern Training Works were started in 1914. Since then, however, the picture has changed very considerably. Although at first we thought it desirable to keep silt out of the Myitmaka as long as possible, it was soon found to be unnecessary to do so. As described later on in Chapter VIII., the Shwele stream gave trouble below the village of Kywethe in 1915, and it was decided to lead the Shwele direct into the Myitmaka two miles above the old junction at Payadu (Map No. 7). Above this new junction the Myitmaka channel became temporarily blocked because the improvement of the Shwele had resulted in silt being carried down to this point and even below it in 1915. The Myitmaka contributed no silt of its own, and the volume of comparatively clear water brought down by it was sufficient to enable it to reopen its connection with the Shwele when the *laha* began to fall later in the year.

From 1915 onwards the Shwele practically appropriated the Myitmaka channel from the junction downwards. Immense quantities of silt came down, and the stream began to behave here in exactly the same way as in the case of all the hill streams in the *laha*. The channel began to enlarge and improve itself by deposits of silt on both banks. When the writer visited the locality in January, 1924, he found a splendid channel nearly all the way to Mindu. What was formerly nothing but a series of swamps given over entirely to fishermen has now running through it a fine stream, with a strip of cultivation continuously along both banks down to the recently established village of Katan.

As indicating that it is more correct to look upon this part of the old Myitmaka channel as now belonging to the Shwele, it may be mentioned that the annually recurring *thegaw* of the Shwele stream is now in it. In September, 1923, after paddling down the Taungnyo stream from Tapun in a dug-out, the writer proceeded by launch up the Myitmaka as far as Payadu, but was then held up by finding only about 2 feet of water. At a later visit in January the channel at this point had resumed its normal depth of about 6 feet; the *thegaw* had been removed, as the *laha* dropped in the preceding October.

For a length of over a mile this part of the channel is just like a canal for straightness. Its origin is remarkable and has already been described in para. 6, and its appearance in the dry season is illustrated in Photo No. 6 (Plate 4).

83. Shwele-Myitmaka Thegaw.—Writing at the end of 1922, Mr. Cheyne described the lower part of the channel as follows :—

"The present condition of the Shwele between Katan and Mindu is very interesting. The rate of formation of banks and of the raising of the ground level can easily be traced for the past four Rains. Briefly put, the rate of bank formation has been about one and three-quarter furlongs a year. The newly formed banks have a breadth of 100 to 120 feet at the end of the second year. Five feet of silt is deposited at the end of the first year's *thegaw*, and the banks are raised to about 10 feet in the second year. The rate in following

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November, 1916. F. A. LEETE.

THE TAUNGNYO STREAM.

54. View from Zibingwe Rest House looking downstream showing the excellent channel between the low bunds, water 10 feet deep.

November, 1916. F. A. LEETE.

THE TAUNGNYO STREAM.

55. View at the downstream end of the low bunds showing boom for holding in logs and bank deposition; gauge marks, starting from the then ground level, were put on trees in June, 1916; when the photo was taken the 5-feet mark was within a foot of the ground.

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years is much slower, as the banks are only topped by very high floods coming down when the *laha* is up.

"In 1922 the bed of the stream between Shwele and Mindu was noticed to have silted up very considerably, in places as much as 3 to 4 feet. The explanation is simple. For many years a licence has been given annually to erect a bridge for the passage of carts across the Myitmaka at Mindu in the dry season. The posts of these bridges have never been removed. Formerly, when silt-laden water never reached Mindu, this did not matter. But when the Shwele silt cone was found to be approaching Mindu last year, the posts should have been removed by the licensee, but this was not done. The result has been that these obstructions have caused a solid deposit of silt at the narrow passage of the Myitmaka between East and West Mindu. This deposit, reducing the bed slope by several feet, has caused the whole bed to silt up for a distance of about four miles, in places as much as 3 to 4 feet. The posts will have to be dug up, and it is expected that the early Rains next year will scour away the greater part of the silt along the whole stretch, and restore the bed of the stream to its former good condition."

When the writer walked down the channel from Kywethe to Mindu in January, 1924, in company with Mr. Cheyne, it was found that the above prediction had been realised, and that the channel had scoured out its bed very completely.

84. The Effect of the Taungnyo on the Myitmaka.—In 1915 the opinion was expressed that the Taungnyo would begin to discharge silt direct into the Myitmaka at Mindu within the next three to five years. The prediction proved to be correct. In Chapter VIII. a description is given of the way in which the Taungnyo stream has been controlled and of the changes that have taken place since 1916. The actual junction with the Myitmaka is now no longer at Mindu. In 1917 the Taungnyo was led along a new line, joining the Myitmaka at Ngapigo, two miles below Mindu. Since then a through channel for the Taungnyo has been maintained and developed. Raising of the banks has been so pronounced that immense quantities of silt have been deposited annually into the Myitmaka for some years past. As in other cases, at the Ngapigo junction when the Taungnyo came down in flood a reverse current was set up in the Myitmaka, causing the channel of the latter to silt up. This was an advantage rather than otherwise, as a bend in the Myitmaka channel was eliminated and a new and straighter channel was formed at the junction. Up to the present no further trouble has arisen. It will be some years before Shwele silt comes down the Myitmaka as far as Ngapigo, as it still has a good deal to do in filling up the big swamp above and below Mindu.

So far as the Taungnyo is concerned, its effect on the Myitmaka is exactly the same as that of the Shwele. The huge quantities of silt now annually brought down are raising the banks of the Myitmaka itself and reclaiming the adjoining low-lying land, as shown in Photo No. 51 (Plate 26). *Thegaws* recur annually with the rise of the *laha*. If there is no late hill rise to wash them out after the *laha* has fallen, then this is done at the first rise in the following season. The point to bring out is that although Taungnyo silt now travels down the Myitmaka for three miles and reaches as far as the Kwethe Yo channel connecting the stream with the Irrawaddy, the nett result has been the improvement of the Myitmaka rather than otherwise. There is no reason

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to suppose that there will be any change for the worse when the Shwele begins to add its quota of silt to this part of the main river.

85. The Future of the Myitmaka.—The Kwethe Yo channel has a very important influence on the *laha*. When the latter is rising, there is a strong current from the Irrawaddy across the Myitmaka from west to east. When the Irrawaddy begins to fall and the *laha* begins to drop, the current is reversed, and a strong flow is set up along the channel towards the Irrawaddy. Allowance for this change in direction of current has to be made in the logging operations, as explained in the remarks about log booms in para. 47.

Although speculation as to the future of the Myitmaka is not at present of great importance, it may not be without interest to make a few remarks on the subject. The writer ventures to think that **if the Myitmaka is left to its own devices,** the combined effect of the Shwele and Taungnyo streams will induce it to make a permanent channel for itself right through to the Irrawaddy *viâ* the Kwethe Yo. Below this junction it seems very probable that the existing Myitmaka channel will silt up and head the waters of the combined streams direct towards the Irrawaddy. With the annually recurring rise and fall of the *laha* and reversal of currents the channels will silt up and cause widespread deposition of silt, so that the country all round the main stream may ultimately be expected to be raised up to the highest flood level of the Irrawaddy and its *laha*.

Such a prediction gives rise to serious misgivings. It will be by no means an unmixed blessing from the point of view either of land reclamation or of the Forest Department's logging operations. Discharge of silt from the hill streams into the Irrawaddy means so much less silt available for reclamation of swamps in the Myitmaka valley. If Shwele and Taungnyo logs pass into the Irrawaddy *viâ* the Kwethe Yo channel, the Forest Department will be put to considerably more expense in delivering them at Rangoon. On both accounts, therefore, the question may well be asked whether it would not be advisable to put obstacles in the way of action on the part of the Myitmaka such as is above suggested. It would seem advantageous to try and block up the Kwethe Yo channel and to keep the existing Myitmaka channel in good order below it.

Although the foregoing remarks are little more than idle speculation at present, it is believed that the problem will eventually become one of great importance. The interval may be as short as ten years, or it may be very much longer. The length of the interval will largely depend on the amount of attention Government desires to have devoted to land reclamation. If the management of the rivers is to be left entirely to the Forest Department without assistance, and if the amount of land reclamation done is to be limited to what local forest officers can attend to without prejudice to the logging operations, the march of events towards the possibilities indicated in the preceding paragraphs will be quicker than if everything possible is done in the way of reclamation of the low-lying land which can be brought within the influence of the Shwele and Taungnyo streams.

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October, 1916. B. P. KELLY.

THE GAMON STREAM.

56. Example of channel training ; no defined channel in 1914 ; leading channel made 18 by 4 feet in 1915 ; besides enlarging the channel, banks formed some distance back on both sides.

October, 1916. B. P. KELLY.

THE GAMON STREAM.

57. Example of an early type of bamboo fencing to induce deposition ; the stakes originally stood 3 feet out of the ground, much closer together than in later years.

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CHAPTER VII

TRAINING WORKS WITHOUT EMBANKMENTS

GENERAL REMARKS

86. Origin of the Training Works.—The modern Training Works originated from a visit to the streams early in 1914 with a view to finding out what could be done with the stranded logs which were known to be scattered about in large numbers.

After looking at the Shwele near Monywagyi the writer walked across country to the Taungnyo stream at Tapun, and he was struck by the fact that conditions on both streams were remarkably similar to each other. The Bawbin was the next stream visited, and when it was found to have many points in common with the Shwele and Taungnyo it did not come as a surprise to find later on that the same remark also applied to the other streams—Myole, Gamon, Minhla and Mokka. Although each stream had some peculiarities of its own, the causes of trouble were everywhere the same. The problem of improving the rivers was the same for all of them.

Starting from the railway, each stream had a broad and deep bed. Walking downstream through permanent cultivation, the channel remained good for a varying distance, but within a few miles of the limit of cultivation the channel became progressively smaller, and evidences of flooding on either bank became more and more numerous. Cultivation stopped at the edge of the low-lying country known to be under water in the Rains. The rivers might almost be said to come to an end here, because the good channels abruptly terminated in a number of small and shallow watercourses, hardly any one of which deserved the name of being a main channel at all.

87. Leading Channels across Thegaws.—The first point noted about stranded logs was that they were not scattered about promiscuously, but that they were lying more or less in strings. This indicated that a strong current had once flowed in their direction. Given therefore a channel deep enough to float the logs, if the current could be kept steady, the logs would remain in the channel, even though the banks were under water. It did therefore seem possible to extract most of the Shwele logs by making a small leading channel right into the *laha* and dragging the logs to the edge of it. Preparations were made accordingly, and soon after the rainy season began in 1914 and the *laha* country was flooded many of the logs were floated right through to the Myitmaka.

Before this had actually happened, however, the thought obtruded itself that these small leading channels might well be expected to improve themselves sufficiently to justify the belief that, if more logs were sent down from the forests, they could also be passed through to the Myitmaka at moderate expense, and without many of them getting lost on the way. There did, therefore, seem to be good ground for thinking that the rivers were not so

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hopeless as was supposed, and that they deserved to be carefully studied. A visit to Tapun in April, 1914, in company with Lieut.-Colonel Nethersole, Deputy Commissioner, Tharrawaddy, and the late Mr. Samuelson, then Executive Engineer, Henzada, confirmed this belief. The matter was referred to Government, but it was decided to wait until the end of the Rains before coming to a decision. When the time came to submit a further report in December, 1914, it proved to be so favourable that sanction was accorded to training works of a permanent character being started, and the services of Mr. Samuelson were made available for the purpose.

HIGH BUNDS (EMBANKMENTS)

88. The trouble with the Shwele began in the twelfth mile from the railway at Kywedegale, where the stream broke up into a number of different channels for a distance of one and a half miles, down to Monywagyi village (*vide* Map No. 4, facing page 61). The channel then improved and continued fairly good for another four miles. To get rid of the bad stretch above Monywagyi a canal was dug for a length of a mile flanked by high embankments. The cost was Rs. 9,125 (£608), and results were excellent during the Rains, 1915. The difficulties above Monywagyi were permanently eliminated.

Serious trouble with the Taungnyo stream began in the eleventh mile from the railway. The river in its wanderings had here come up against the embanked and metalled road from Paungde to Tapun, and in its efforts to cross the road broke up into a number of small and irregular channels for a distance of about one and a half miles (*vide* Map No. 5, facing page 61). On Mr. Samuelson's advice, a canal was dug one and a half miles long across this bad stretch from Tagyo to Zibingwe (*vide* Map No. 7, end of book). The canal was flanked on both sides by high embankments, which were continued upstream for another mile and a half to Thakuttan, where overflow from the main stream was strongly in evidence. The cost of these training works was Rs. 55,527 (£3,702). During the Rains, 1915, they answered their purpose admirably ; a good stream right down to Zibingwe was obtained.

The big embankments on the Bawbin stream made in 1915 have already been described (Chapter VI.). Expenditure was Rs. 40,867 (£2,724).

The only other stream on which double embankments were made in 1915 was the Minhla (*vide* Map No. 9, end of book). As in the case of the Shwele and Taungnyo streams, these embankments were constructed at the critical place where the stream showed signs of persistent flooding and straying of logs. The cost was Rs. 8,641 (£576), and during the Rains, 1915, the embankments accomplished their object in inducing the river to lengthen its good channel.

LOW BUNDS (EMBANKMENTS)

89. The above summary brings big embankment projects to an end, as no more were undertaken in subsequent years. At the end of the Rains, 1915, although a good channel had been obtained down to the lower end of the Taungnyo embankments at Zibingwe, we were left with no good channel below there, and with some 3,000 logs spread out fanwise over a large area.

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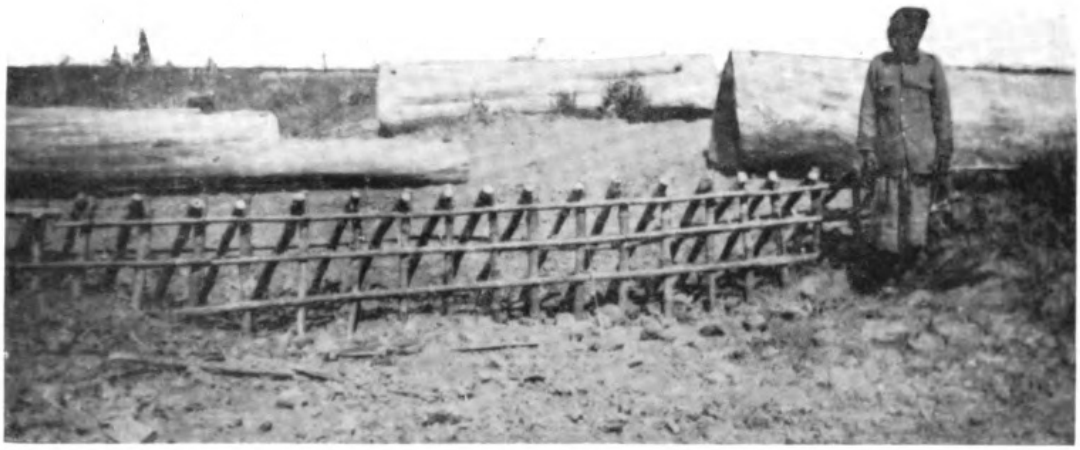
December, 1922. T. MARLOW.

BAMBOO STAKE FENCING.

58. Usual type since 1917 ; the stakes shown in the picture originally stood 3 feet out of the ground.



December, 1922. T. MARLOW.

BAMBOO STAKE FENCING.

59. Strutted type of fencing, used where extra strength is required, not so much used as the more simple type.

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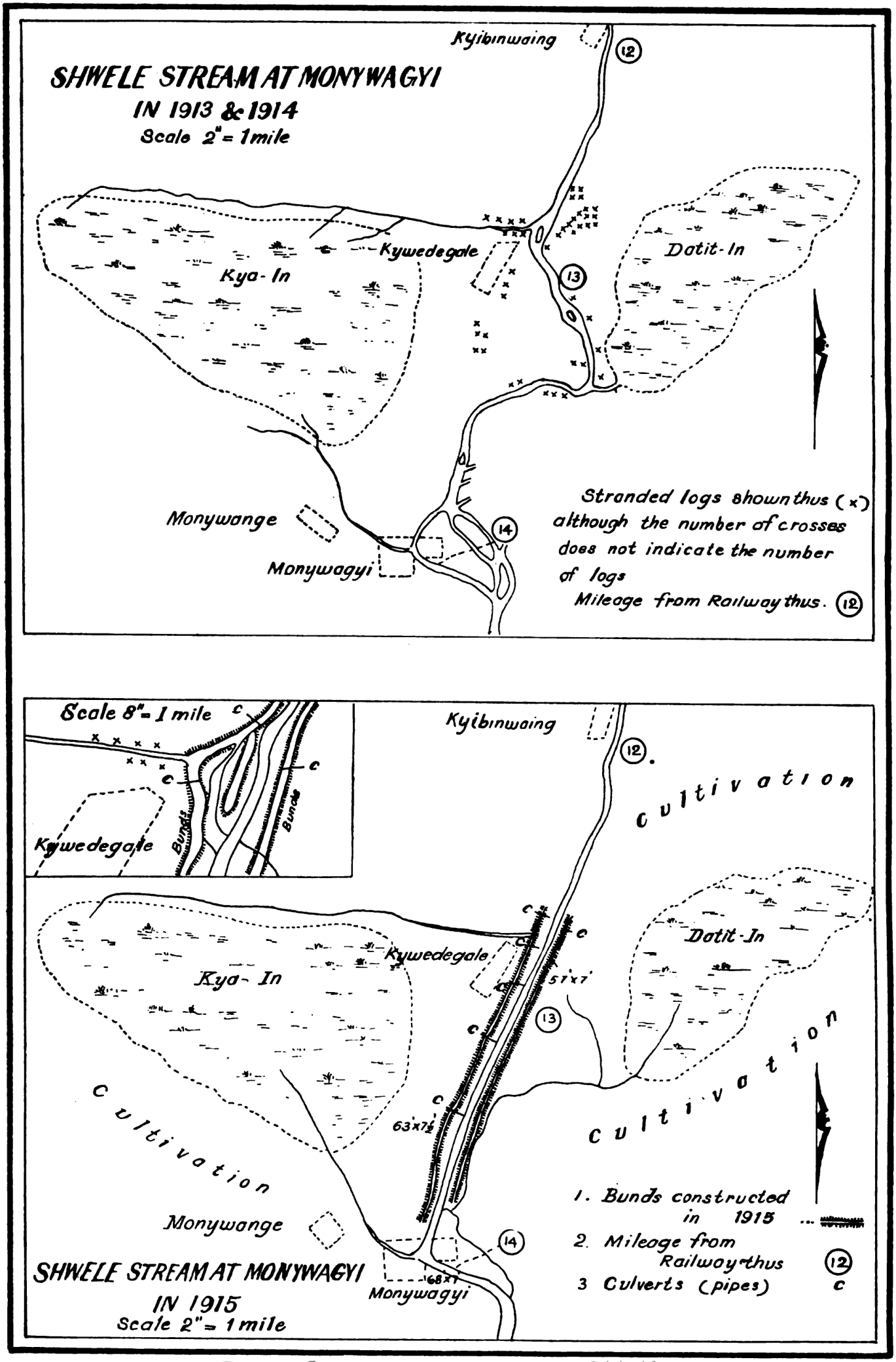
Map No. 4.



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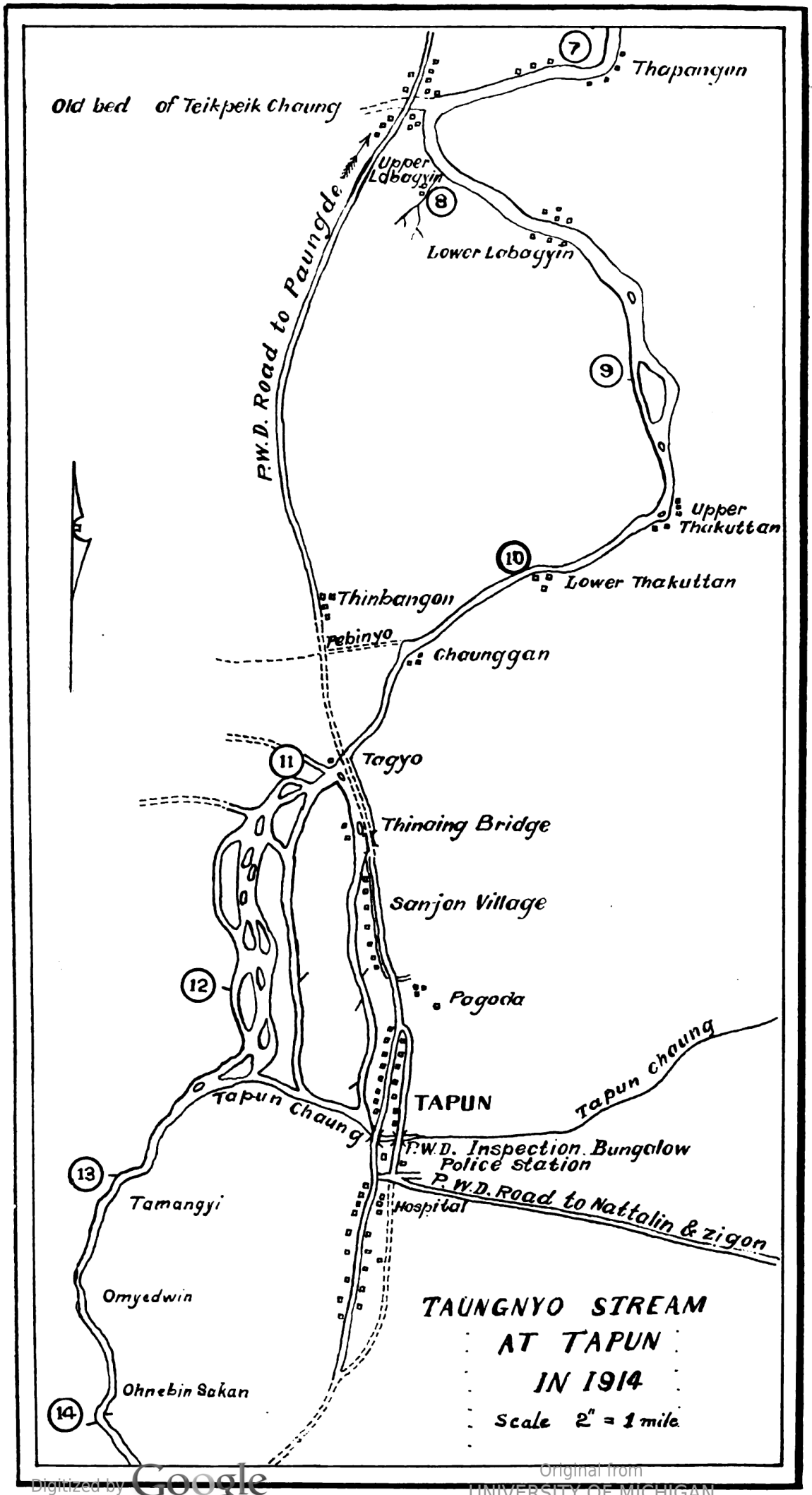
MAP No 5.



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The disposal of these logs has already been described in Chapter IV. The problem to be solved was what to do to improve matters in the future. Mr. Samuelson strongly advised extending the big embankments as far as funds would permit, but this proposal did not commend itself to local officers. It was argued that if a good part of the flood water could be got rid of on the way —by allowing it to flow over low embankments—there would still be enough left to float out logs. On arrival at the end of these low bunds a good part of the force of the floods would have been eliminated, and so logs would not be so likely to leave the channel. This proposal was carried through at a cost of Rs. 23,081 (£1,539). A canal flanked by low embankments 3 feet high was dug for a length of a mile (*vide* Map No. 7, end of book).

During the Rains, 1916, there were some critical times, but the low bunds did serve their purpose admirably. A good channel was formed, and logs left stranded were not badly placed. The big accumulation of stranded logs left behind in 1915 was spread fanwise over a large area, and it was a laborious business to get them ready for floating in 1916. The accumulation was quite as large at the end of the Rains that year, but the logs gave next to no trouble because they were left strung out alongside the channel for a mile or more. As was hoped, the floods had not been so unmanageable owing to the amount of water got rid of through the sluices. Photos Nos. 52 and 53 (Plate 27) may serve as illustrations. They were taken in September, 1916, in the open channel below the lower end of the low bunds, after a rise bringing down logs. As may be seen from the photographs, the logs kept to the channel although it was only a small one, about 20 feet wide. It was the same thing with later log-bearing rises in the season.

Photo No. 54 (Plate 28) speaks well for the channel that was developed between the low bunds in 1916. Photo No. 55 contains several details of interest. It was taken just below the ends of the bunds, and shows the boom for keeping logs to the channel. It also shows how banks rise by deposition. When the writer was at Tapun in June, 1916, *after* the flood season had begun, he suggested putting gauge marks on any trees handy, starting with zero at ground level. When the photograph was taken in November the 5-foot mark on the tree in the picture was within a foot of the bank that had formed.

There is no wish to gloss over the fact that the low bunds were a failure in one respect. It was expected that they would remain more or less intact even though flood water passed over them. With this idea in mind, the bunds were made extra wide—30 feet —and were protected with grass and brushwood to check erosion. But breaches were numerous in spite of all that was done, and if it had not been for the big deposits of silt caused by the flooding, the bunds would have been practically wiped out altogether. The lesson learnt was that such bunds were really of little use at all, and in no respect better than the stake fencing method of control suggested by them and described in the following paragraphs.

NO BUNDS (TRAINING WITHOUT EMBANKMENTS)

90. The low bunds of 1916 just described were the only ones of their kind, as local officers came to the conclusion that even better results could be obtained without them.

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Sluices.—In the notes on sluices in Chapter V. it is remarked that in the Rains, 1916, there were very big deposits all round the outside of the two big sluices in the low bunds and also on both sides of the lower ends of the embankments themselves. The conclusion forced itself upon us that equally good, if not better, results could have been obtained without any earth bunds at all. This conclusion was confirmed by experience gained during the same year on the Gamon stream. Without any artificial embankments the river had been induced to lengthen its good channel for a considerable distance. All that was done was to dig a small leading channel and to put rows of stakes some distance away on both sides. The stakes were placed much closer together than in later years, but they did do good. During the Rains rubbish collected at the stakes, and considerable deposition took place, well illustrated in Photo No. 57 (Plate 29). The stakes in the picture originally stood 3 feet out of the ground. At the end of the Rains the river was found to have formed well-defined banks for over half a mile. Photo No. 56 shows the banks well. A shallow ditch had been developed into a substantial river channel.

Early in 1917 preparations were made to apply the bamboo stake fence method to all the streams. It was a brilliant success. Each succeeding year has shown equally good results, so that this system of river training can be looked upon as having passed its experimental stages and become a permanency.

91. Removal of Floating Obstructions.—Before going further, and at the risk of repetition, emphasis may well be laid on the fact that this method of controlling the streams, without the help of high embankments, would have been an absolute impossibility unless proper attention had steadily been paid to the removal of floating obstructions and the proper handling of logs. If rubbish had been left to accumulate on the *thegaws* and if logs had been allowed to remain just as they happened to lie after a rise, and often effectually obstructing the channel, when the next floods came the rivers would certainly have got beyond control. The lesson learnt was that attention to the proper disposal of logs must on no account be relaxed, and even where there is no logging at all there must be no reduction in the efforts made to keep the streams clear of floating obstructions.

92. Stake Fencing (by Mr. Cheyne).—Since 1916 no bunds whatever have been made on any of the streams. The continuation of all channels into the *laha* area has been brought about and controlled by means of simple bamboo fences. The method is simplicity itself.

For purposes of description of the manner in which the " no bund " method is applied an average state of affairs in any stream at the end of a rainy season may be considered, and reference is invited to Fig. 5 (facing page 63). The condition of the stream is that a channel has been formed and kept in place by herring-boned rows of logs (B). Below this point the channel for some distance is clearly defined in the silt deposits, the late rises having scoured a passage through the fan of silt thrown out in front of what may be considered the stream mouth. Side channels from this passage have been blocked with logs (C). Below this the channel is merely a depression in the stiff *laha* clay. The line along which it is desired to form the new channel is then pegged out and usually follows more or less this natural depression. All jungle growth to a width of 150 feet on each side of the line is cut down flush with the ground

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March, 1924. G. C. CHEYNE.

THE MYOLE STREAM.

60. View in tenth mile, showing preparations for the Rains, 1924; note the depression along which the stream is to be led and the arrangement of logs.

March, 1924. G. C. CHEYNE.

THE MYOLE STREAM.

61. Another view of the same part of the stream; note the strutted bamboo fencing across a side channel.

[*To face p.* 62.

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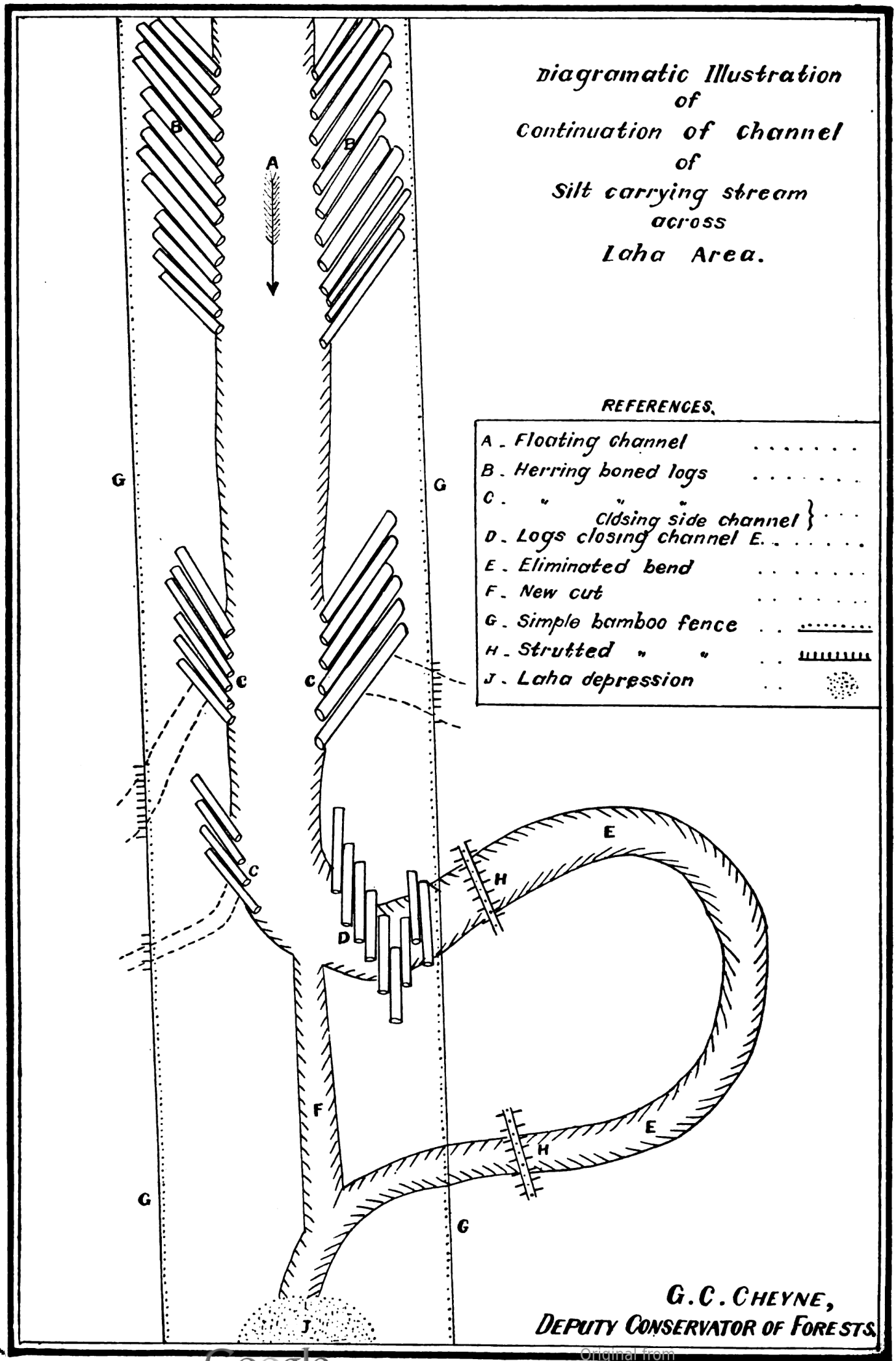
Fig. 5.



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and burned or cleared away. One hundred feet on each side of the line simple bamboo fences are made. These consist of pointed bamboos, 5 to 6 feet long, driven into the ground about 9 inches apart, with their tops dressed to a steady slope and about 3 feet above ground level. These stakes are lashed to a horizontal rail with coir rope about 6 inches from their tops to hold them in position. Where this fence crosses side channels the bamboos naturally stand higher out of the ground, and must be strutted to withstand the additional pressure at these points. Bad bends (such as D) are eliminated by short-cuts (F), and protected by additional strutted fencing. A point to note in making a leading channel or cut, where scouring may be expected to take place, is that economy can be effected by digging to the desired depth in steps, as indicated in Fig. 9 (facing page 69).

Photo No. 58 shows a length of the simple type of stake fencing after it had been buried to a depth of over 2 feet by deposits. Photos Nos. 49 (Plate 25) and 59 (Plate 30) show the strutted type.

The low fences are continued just beyond the point which it is anticipated will be the limit of the main silt deposit of the ensuing Rains. Much the same remark applies to jungle clearing. There would be no particular point in extending the preparations further ahead in advance of the development of the good channel. An axiom of general application underlies this remark. **Nothing useful can be done far in advance of channel formation.**

93. During the early rises, before flood conditions obtain in the Myitmaka valley, the watercourse being only a depression in more or less level ground, the water tends to spread out over the country. It is at this time that the fences do their best work. They catch up the many kinds of small rubbish brought down on every jungle rise, and form a barrier checking the flow of the water. A considerable quantity is bound to come down, in spite of cleaning operations in the preceding dry season. The check to the current causes it to deposit the heavier particles of sand on the stream side of the fence, the finer particles being carried beyond it. In this way each rise serves to heighten the banks now forming, as well as to raise the level of the surrounding country.

It is obvious that in using these fences it is essential that they should be kept in a proper state of repair, for the least breach defeats their object of securing an even overflow of silt-laden water and the consequent even deposit of silt. Results are almost always good, and they are sometimes astounding. Cases have been known of the fencing being completely buried in a single rise. No trace of its existence may be left, as deposition of silt is remarkably uniform. Before any deposit takes place the ground may be apparently level as far as the eye can reach. It may still appear to be equally level although uniformly raised several feet by deposits.

After the first row of stakes has been buried a second row may be put up, but this is not often necessary. It is only during the preliminary stages, when the channel is small, that assistance is required to induce the river to keep to it. Deposition goes on steadily for a number of years, at first rapidly and then more slowly, until the stream has formed for itself a channel large enough to contain practically all its normal flood water.

Long before this stage is reached the land on either side has become permanently culturable. As a matter of fact, cultivation begins much earlier.

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As soon as the semi-liquid mud begins to show up cultivators begin transplanting their paddy. Even though at subsequent floods the plants may be buried a foot or two deeper, a good crop is obtained, of sufficient value to repay them for the trouble of growing it.

94. A few remarks may be made about the various pictures of channel formation in the book.

Photos Nos. 4 (Plate 3), 60 and 61 (Plate 31), are three views of the preparations made for extending the good channel of the Myole stream in the tenth mile into the *laha* in 1924. So many different views are reproduced because each of them brings out some details not conspicuous in the others. It is rather a pity that more illustrations of this very important phase of the Training Works are not available. Points to be noted are—(1) the very shallow depression down which it is hoped to lead the stream : the digging of a leading channel has not been considered necessary, (2) the herring-boning of logs on both sides, (3) the bamboo stake fencing of the simple type shown in Photo No. 58, and (4) the strutted type of fencing across a side depression.

Two miles upstream the Myole has a broad and well-defined channel, 48 feet × 7 feet 6 inches in section, entirely formed by deposits, and at the end of the Rains, 1924, a channel from 30 to 40 feet wide and from 3 to 5 feet deep may with confidence be expected at the place where the photographs were taken.

Photos Nos. 62 and 63 (Plate 32) show stages in the training of the Taungnyo stream in the fourteenth mile in 1919. A picture of this part of the channel in 1923 would be exactly like the frontispiece, although the latter was taken further downstream in the fifteenth mile, and belongs to the series of photographs in Plates 33 and 34. This group of pictures illustrates what is locally known as the Ayokma Cut, where a bad bend in the channel was eliminated in 1919. All that was done was to make a broad clearing through the dense jungle and to dig a leading channel, 2 × 4 feet, down the middle of it. The old channel was blocked by fencing and a log boom.

95. Thegaws on Streams.—All the hill streams have shallow places (*thegaws*) in the neighbourhood of the *laha*. The *thegaws* are constantly changing in the course of the rainy season both as to position and as to degree of silting up. It may, therefore, be as well to consider the matter in some detail.

The effect of variations in the height of the *laha* on the place of deposition of silt along the banks is referred to in para. 22. The commencement of deposition may take place anywhere within a length of about two miles, according to circumstances. Considerable quantities of sandy silt are carried forward still further, so that the total length of channel under formation is about three miles. When a flood begins to fall, deposition in the bed begins to travel upstream, and by the time a rise has ended what was a good channel at the beginning of it may have been more or less completely silted up for a greater or shorter length ; below the bed of a stream there may be sandy deposits to a depth of 2 or 3 feet or more. In other words, the bed is this much higher than the *laha* some distance away on either side. The state of affairs is therefore one of unstable equilibrium. If a breach occurs anywhere in the banks it may be difficult to prevent its developing into the main channel, the old one becoming blocked up lower down. Within limits no great harm

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May, 1919. T. MARLOW.

THE TAUNGNYO STREAM.

62. Training the stream in the fourteenth mile without embankments, small leading channel dug and logs herring-boned.

December, 1919. T. MARLOW.

THE TAUNGNYO STREAM.

63. The same as the above after one rainy season, banks 7 to 8 feet formed.

[*To face p.* 64.

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would result from such a diversion, but sharp bends in a stream may cause trouble with logs, and are certainly to be avoided in a permanent channel. It is, therefore, advisable to try and keep the small channels into the *laha* as straight as possible.

96. Rate of Development of Good Channels.—In para. 13 a table is given showing the distances by which the limit of cultivation has moved downstream whilst the Training Works have been in progress. The same figures may also be applied to the rate of progress on the part of the streams in forming good channels for themselves, that is the rate at which the *thegaws* have moved downstream. In the case of the Shwele, Taungnyo, Myole and Gamon streams, in a period of eight years, the average development of good channel has amounted to almost exactly half a mile per annum. The good channel of the Minhla, such as is described in the later paragraphs of this chapter, only began to form in 1919, and up to the end of 1922 it advanced two miles, so that the average here is also half a mile per annum. It is much the same with the Mokka. It may, therefore, be taken as a general rule that all the streams develop half a mile of good channel annually. Such a factor may be applied to any similar stream elsewhere, similar, that is, as to amount of water, silt and slope.

97. The Minhla Stream in 1923.—The photographs and cross sections of the Minhla stream in 1923 will well repay careful study. The evolution of the stream is remarkably easy to follow. If it were desired to make a series of diagrams for the purpose of illustrating the normal behaviour of any one of the hill streams in and near the *laha*, one could not do better than make large scale drawings of the Minhla and Gamon streams as they are to-day. The streams run fairly straight into the *laha*, and there are none of the complications which have made the story of the Shwele and Taungnyo streams, during the nine years they have been under training, so much more difficult to follow.

When the writer made a tour of the streams by launch in September, 1923, the *laha* common to the Gamon, Minhla and Mokka streams was a vast unbroken sheet of water several miles wide. At Tanbingon the banks of the Myitmaka were 2 feet under water. We proceeded across the *laha* by launch for about three miles to the Sunsa log depôt. Inside a big boom were some 25,000 logs all afloat, the watchmen's huts being on rafts. A quarter of a mile further on the water in front of us suddenly began to shallow, and not more than 200 yards distant what looked like the end of a small canal, with the banks just showing, was visible (*vide* Photo No. 68, Plate 35). There were a number of logs evidently stuck in the mud alongside. Transferring ourselves to a dug-out, we were paddled to within 50 yards of the logs, and then the boat was dragged into the end of the canal itself. The writer then stepped on to the bank and took Photos Nos. 69 and 70.

98. Minhla Thegaw in September.—Mr. Cheyne stated that a deep channel some 40 feet wide and 6 feet deep had existed earlier in the year right into the *laha* six and a half miles from the railway, but that it had silted up solid for a length of 100 yards at the last rise. The small leading channel shown in the photographs had just been dug, and stranded logs were being arranged herring-bone fashion on either side of the stream further up.

At the top end of the *thegaw* the channel widened to about 50 feet and a depth of about 3 feet with the banks showing a foot above water. About a mile

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upstream we came to the ranger's house, five and a half miles from the railway. As evidence of the rapid rate at which the ground level was being raised it may be mentioned that when the house was built early in 1923 the lower floor was 4 feet above ground level. At the time of our visit the floor was only 2 feet above it. Half a mile further upstream we came to permanent cultivation, which showed very little signs of flooding, although a certain amount of deposition still takes place from time to time.

At this point the paddy fields extended for fully a quarter of a mile on either side. Beyond that distance water could be seen. Looking downstream, the brilliant green strip of paddy could be seen to gradually narrow down to a width of 40 to 50 yards close to the top end of the *thegaw*. Panoramic Photos Nos. 2 and 3 (Plate 2) give an excellent idea of the landscape.

99. Minhla Thegaw in November, 1923, and January, 1924.—On November 13th the writer had another look at the Minhla *thegaw*, this time riding down from the railway. No big rise had occurred since our first visit in September. The upper portion of the stream looked much the same as before, except that the banks seemed higher, owing to there being only a foot or two of water in the stream. **But all the water had gone from the laha,** and mud was showing everywhere. A remarkable change had also taken place on the *thegaw*. The day before our visit a small rise had occurred, and although the water was not more than a couple of feet deep, it was rushing hard down the steep slope of the *thegaw* channel, which was visibly scouring out very fast indeed. If Photos Nos. 69 and 71 (Plates 35 and 36) be compared, the amount by which the channel had enlarged itself in two months can be judged. We were told that it is next to impossible to paddle a boat upstream when the river is in full flood, and after seeing the channel we had no difficulty in believing it. Two months later (January, 1924) Photo No. 72 was taken. Although no big rise had occurred since November, the channel was 50 feet wide and 12 feet deep, all of it accomplished by scouring out the *thegaw*.

The banks at the end of the channel were a remarkable sight. They stood up for all the world like artificial embankments. Walking away from the edge of the channel, within a distance of 100 yards there was a drop of fully 10 feet. Photo No. 11 (Plate 6) shows the high *laha* flood mark on a tree 12 feet above ground level.

The appearance of the channel further down in the *laha* is illustrated in Photos Nos. 12 and 13 (Plate 7), and recently buried logs are mentioned in para. 50 (*vide* Photos Nos. 44 and 45, Plate 23).

100. Cross Sections of Streams.—The cross sections of the Taungnyo in Fig. 1 (facing page 15) show how remarkably uniform deposition has been. The slope away from the channel is between 2 and $3\frac{3}{4}$ feet for a distance of 1,000 feet. None of these sections were taken as far downstream as the *thegaw* itself, as that was right in the Myitmaka. The Minhla cross sections (Fig. 2, facing page 15) show greater variations because they were taken nearer to the more recently formed channel. Section No. 3 is on the *thegaw* close to the end of the good channel, at the same place as Photos Nos. 69, 71, and 72.

In a distance of 500 feet from the bank there is a fall of 9 feet on one side and $10\frac{1}{2}$ feet on the other. The depressions shown in the section indicate the direction of flow at big breaches which occurred just above the *thegaw* (*vide*

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May, 1919. T. MARLOW.

THE TAUNGNYO STREAM.

64. Ayokma Canal in fifteenth mile, dug 20 by 4 feet, looking upstream.

May, 1919. T. MARLOW.

THE TAUNGNYO STREAM.

65. Ayokma Cut looking downstream, showing old deserted channel on the left and the canal on the right.

[*To face p.* 66.

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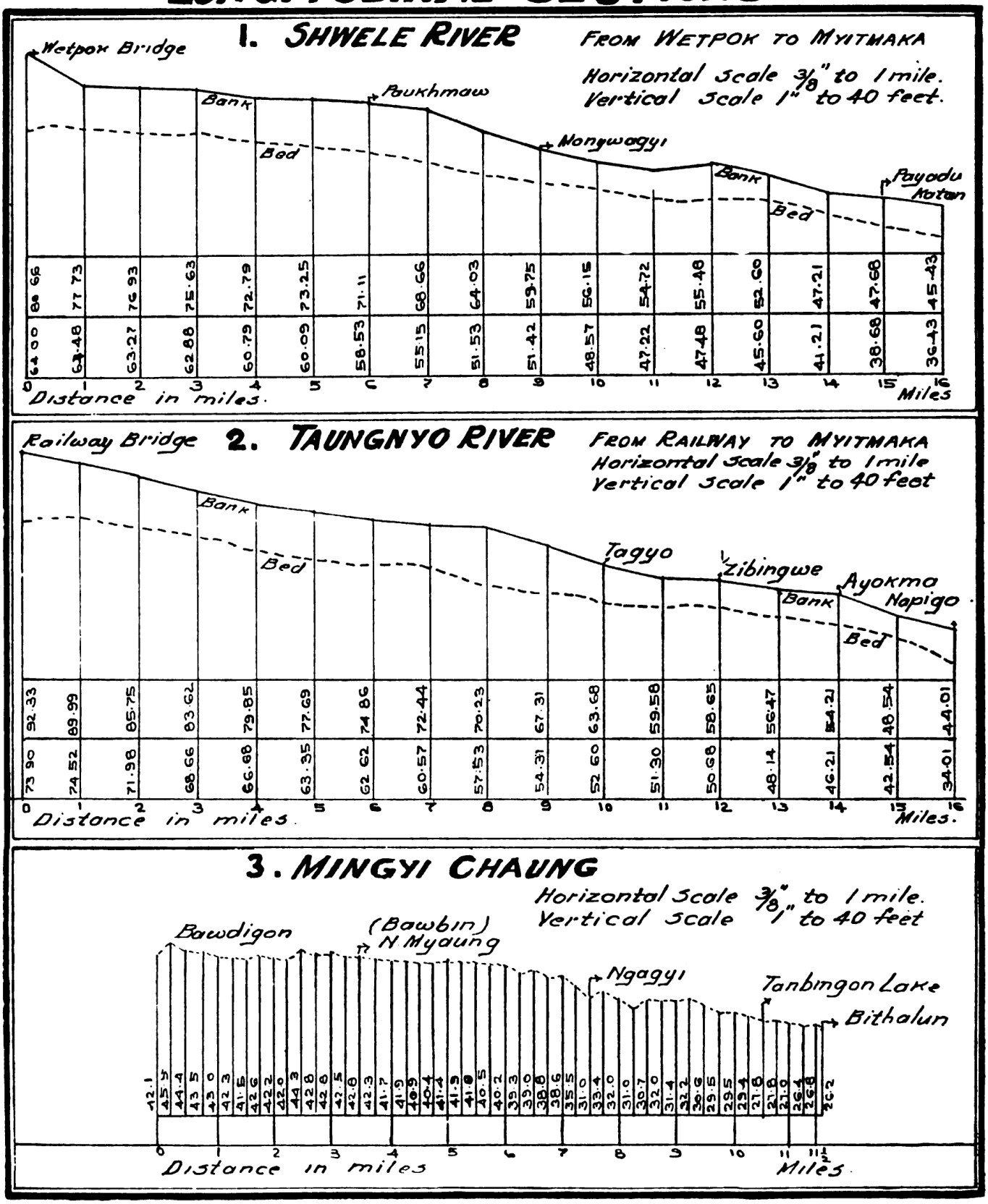
Fig. 6. **LONGITUDINAL SECTIONS**



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MYITMAKA VALLEY CROSS SECTION 1908

Along the Proposed Letpadan-Tharrawaw Railway Line

Horiz: Scale - 1 inch to 3 miles
Vert: Scale - 1 inch to 40 feet

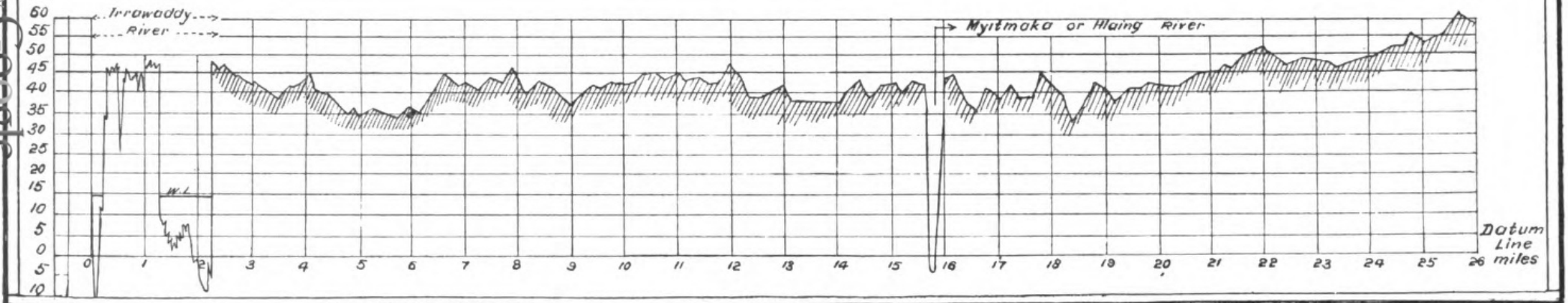

FIG. 7.

MINHLA CHAUNG-LONGITUDINAL SECTION-December 1923

(Railway to Myitmaka at Tanbingon)

Horiz: Scale 1 inch to 1 mile
Vert: Scale 1 inch to 40 feet

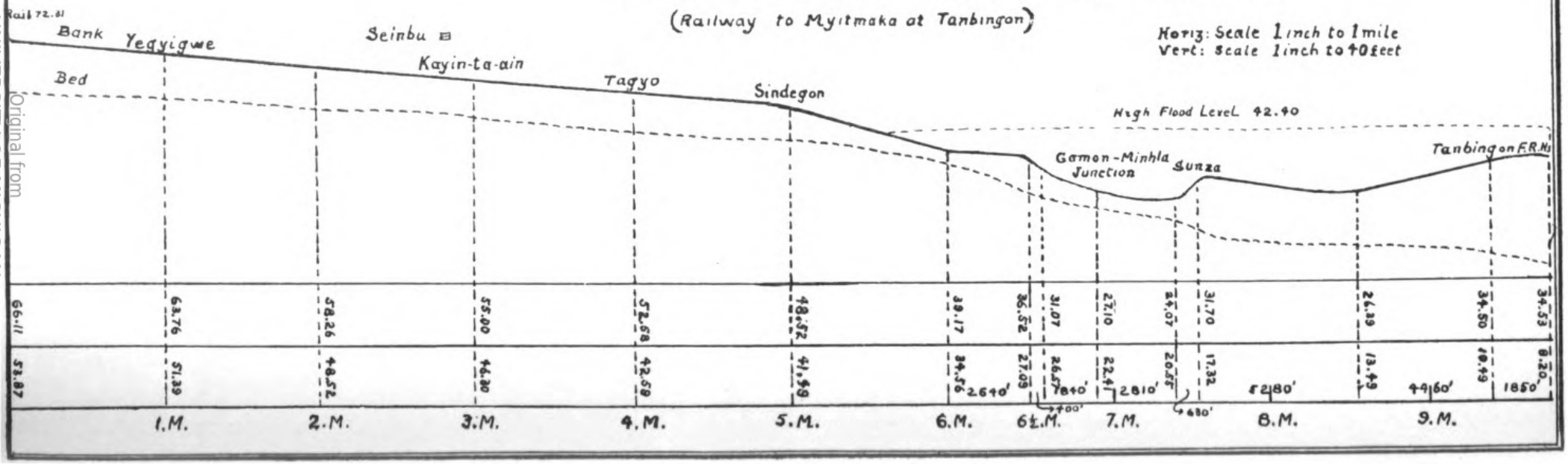

FIG. 8.

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the left bank overflow in Photo No. 70). Next season Section No. 2 will flatten out and become like No. 1, and No. 3 will pass into the stage at present represented by No. 2. If a fourth section were taken at the end of the 1924 good channel, it would be found to be like the present No. 3, and be about half a mile further downstream.

101. Longitudinal Sections of Streams.—The Minhla longitudinal section (Fig. 8, facing page 67) is very striking. The more or less fully formed channel in the river's own deposits extends down to the fifth mile from the railway; the bed and banks are remarkably uniform in slope, 2·5 and 3·5 feet per mile (1 in 2,110 and 1,510) respectively. From here to the end of the good channel, in a distance of one and a half miles, the bed and bank slopes increase to 9·6 and 8·0 feet per mile. The stream then passes down into the deep *laha*. The junction with the Myitmaka at Tanbingon is about nine and three-quarter miles from the railway. The slope of the bed from M. 6½ down to the Myitmaka averages 5·8 feet per mile. In the last two miles, however, the ground level rises; at Tanbingon it is only 2 feet lower than at 6½ M. This bears out the remarks made in para. 16 about the raised banks along the Myitmaka.

The longitudinal section also shows why the stream is able to scour out its *thegaw* so effectively when the *laha* falls. There is no reason apparent why the river should not continue to do so, as the good channel travels downstream. Between the railway and Tanbingon there is a difference in bank level of 31·6 feet in nine and three-quarter miles, or 3·2 feet per mile. This is practically the same as in the permanent channel, five miles in length, that has already been formed. The average slope of the bed is even greater (4·6 feet per mile).

These figures are only approximate, as a more detailed survey might show slightly different results; but they are sufficiently accurate to dispel any fear that may be entertained as to the inability of the Minhla to maintain a good channel, with so much water lost on the way by irrigation cuts, breaches and general overflow.

102. Regulation of the Line of the Channel in the Future.—In the case of the Gamon and Minhla streams, it is obviously a simple matter to develop a good channel, but a more difficult problem to be solved is the checking of discharge of silt into the Myitmaka. This clearly ought to be done because the *laha* is so extensive. If the combined streams continue in their present course, within another two years they may be expected to have travelled right across the very low ground shown in the section between M. 6½ and Sunza at M. 7½.

Good as the channels developed in recent years are, the fact remains that both the Gamon and the Minhla are practically running in relatively shallow depressions on the top of embankments formed from their own deposits. One reason why the width of the Minhla deposits half a mile above the 1923 *thegaw* is so great is that the stream broke through its left bank here and followed another course into the *laha* in 1922. It took some time to close the breach; it was, in fact, not effected until large deposits all round in front of it had taken place. The next time a breach occurs somewhere else it may be preferable to let the river stick to the diversion.

But even if this does not happen, when the good channel reaches Sunza, the direction should be changed in order to fill up the low ground that will have been left on both sides. Unless diverted, the combined streams are

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certain to head in the direction of Tanbingon for several years to come, but there is no reason why they should not take a number of different lines to get there. It is evident that it would be a simple matter to divert the flow southwards in the neighbourhood of Sunza by causing the Tanbingon channel to silt up. All that it is desired to bring out here is that it does not matter much what line the streams take, and how often they change it, provided that they are looked after, and that depressions between adjacent lines are methodically filled up by deposition. When a change in direction is indicated a certain amount of compensation may have to be paid for passage across established cultivation; that is all. Such compensation might not be called for if the streams were allowed to make the first move in the desired direction. Remarks such as the above about the ease with which river channels can be changed and controlled may sound rather nonsensical, but they are sober fact.

GENERAL CONCLUSIONS

103.—The foregoing study of the Minhla and other streams in Tharrawaddy indicates general conclusions applicable to rivers elsewhere which are of a similar character, that is, to *silt-bearing streams with channels that are not large enough to carry all their normal flood water.*

Such streams are in a state of development; in their higher reaches the channels may be adequate, but lower down they are certainly not so. Whenever one of these streams comes down in flood, general bank overflow occurs, and the network of temporary channels is on a small scale exactly similar to the delta of a big tidal river.

The main river into which the streams discharge may or may not be liable to overflow itself. The behaviour of the hill streams will be essentially the same in both cases. In Tharrawaddy overflow from the Irrawaddy causes the widespread inundations in the Myitmaka valley from which the name *laha* is derived. If the Irrawaddy were kept out by an embankment, there would still be flooding, but to a much smaller extent. The hill streams come down in flood a dozen or more times during the monsoon period, and every time they do so bank overflow takes place from the point where the channels are too small, no matter whether the *laha* is high or low.

What rules should govern engineering works connected with **the parts of river systems where channels are not yet large enough to carry normal flood water?**

Three rules may be formulated. They are really nothing more than axiomatic, but want of attention to them may lead to heavy expenditure without tangible results.

Rule 1.—Anything in the nature of embankments would be a mistake under any circumstances and for any purpose, *i.e.*, whether for training the river itself or in order to carry a road or railway in any direction.

Rule 2.—In advance of the river itself nothing useful can be done beyond the removal of obstructions, felling trees, cutting shrubs and grass and making the preparations outlined in para. 92 in order to induce the stream to follow any desired line.

Rule 3.—The general direction in which a stream tends to go should ordinarily be followed, because this indicates the lowest ground.

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December, 1919. T. MARLOW.

THE TAUNGNYO STREAM.

66. Ayokma Cut looking upstream from the same place as No. 64, after the Rains, 1919.

December, 1923. B. D. LLOYD.

THE TAUNGNYO STREAM.

67. Ayokma Cut at the end of the Rains, 1923, *i.e.*, after five rainy seasons; note the excellent channel and the permanent cultivation (paddy), the posts holding the boom blocking the old channel still in position, together with a few logs.

[*To face p.* 68.

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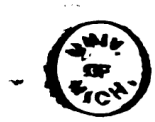

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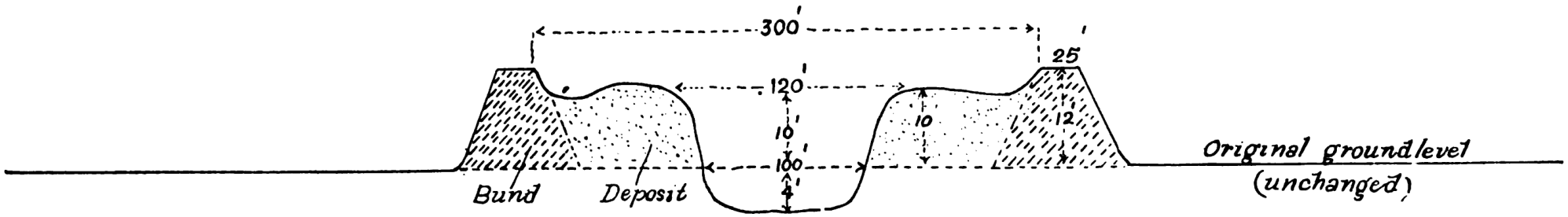
Fig. 9.

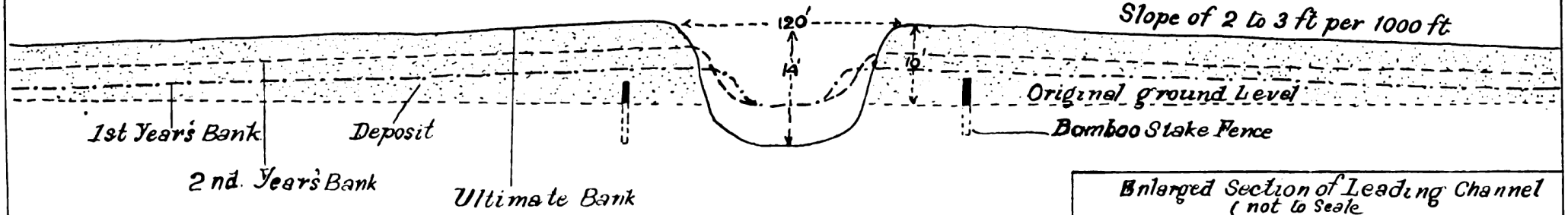
HIGH BUNDS

(Training with Embankments)



NO BUNDS

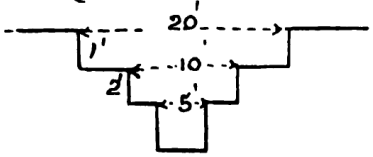
(Training without Embankments)



Horizontal Scale, 1" = 100 feet.

Vertical Scale, 1' = 20 feet.

Enlarged Section of Leading Channel
(not to Scale



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104. River Training by Embankments.—Proposals for embanking streams which have not developed big enough channels for their needs when in flood should be received with very great caution. At the lower end, where channels are extremely small and variable, embankments should be ruled out absolutely. There should be no exception. Travelling upstream, as conditions improve (generally through the action of the river itself in raising the ground level by deposits), a stage may be reached where there may be a case for embankments.

The diagrammatic sections in Fig. 9 (facing page 69) speak for themselves. The ground outside big embankments is left for all time at its original low level. Any breach in the bunds may result in large areas of cultivation being buried under huge deposits of silt, to say nothing of the possibility of permanent diversion of the river itself.

There is no comparison between the two methods of training in respect of the stability of the topographical conditions set up by them. If recourse is not had to embankments big breaches are a practical impossibility. The worst that can happen is temporary inconvenience caused by widespread flooding to a depth of a few inches.

From the point of view of capital expenditure on construction and recurring expenditure on maintenance, the balance leans still more heavily in favour of a **no-bund** policy until the stream under reference has made considerable progress towards building up an adequate channel for itself. By the time this has happened the land alongside will generally be under permanent cultivation. It may well, therefore, be desired to protect crops from extra high floods by putting up embankments along the channel, but they will only be low ones, comparatively inexpensive to build and to maintain.

Cases may also arise where on economic grounds it is deemed to be imperative to afford immediate protection to cultivation and property by means of embankments. The slower method of protection involved in letting the streams build up banks for themselves might cause too much discontent amongst the local people. Even so, before a start is made with the embankments, efforts should not be spared to try and make the people understand that they would in the long run benefit by putting up with the temporary inconvenience caused by flooding for a few years.

The big embankments made on the Shwele, Taungnyo, Bawbin and Minhla streams in 1915 had their use. Without the confidence afforded by them Government would in all probability not have sanctioned the Training Works at all. It is nevertheless true that, if the clock could be put back to 1915 without depriving us of the experience acquired since then, the bunds would never have been proposed at all. It can with confidence be stated that the Tharrawaddy rivers could all of them have been controlled by stake fencing alone, and without any appreciable loss of time. The embankments have served their purpose, but they are no longer doing any good, and it would be a sound move to take steps to abolish them. The low ground outside should first of all be raised by means of sluices. Several cuts have already been made.

105. Proposed Embankment of the Left Bank of the Irrawaddy.—Reference is invited to the remarks already made in para. 21 on the subject of the proposed Talokmaw-Yandoon embankment of the Irrawaddy. The

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present rate of progress with reclamation in the valley of the Myitmaka, namely, about two square miles a year, may be relied upon to continue, but there is no getting away from the fact that it is slow compared with the huge amount that remains to be done before the whole of the *laha* (650 square miles) becomes fit for permanent cultivation. There may, therefore, well be plenty of room for giving full consideration to any scheme by which progress would be accelerated. The proposed embankment of the left bank of the Irrawaddy would do this, because it would have an immediate effect in reducing the extent of the flooded area or *laha*.

Fig. 7 (facing page 67) is a cross section taken in 1908 along the route afterwards followed by the Letpadan-Tharrawaw railway line. It gives some idea of the nature of the problem involved in embanking the Irrawaddy.

The main proposal, to keep out the flood waters of the Irrawaddy, is quite sound from the point of view of the interests of the Tharrawaddy District. The rules laid down in the preceding paragraphs do not apply to this part of the project, because the water that flows in from the Irrawaddy is not heavily charged with silt. It can, therefore, have only a very small effect in raising the general level. After levels have been subsequently raised by deposits from the hill streams the embankment would be correspondingly less expensive to maintain.

The other part of the project now before the Government is quite unsound, namely, to put sluices in the embankment in order to help the Myitmaka to maintain a through channel. It was thought that the Myitmaka would not be able to do this without assistance when the hill streams discharged their silt into it. Any attempt to help the Myitmaka in this manner would obviously result in large quantities of silt being carried down towards Rangoon instead of being utilised in reclaiming low-lying ground. Swamps and depressions at present cover something like 50 per cent. of the area affected by the annual inundations. If the Irrawaddy were kept out, they would still remain until blotted out by deposits.

The necessity for the sluices is not apparent. There is no reason why the Myitmaka should not be able to raise its own banks sufficiently to form a channel large enough to carry flood water any more than in the case of the hill streams flowing into it.

106. Road or Railway Embankments.—Roads and railways have been constructed in the past in tracts where silt-bearing streams have not developed adequate and permanent channels. Similar projects may come up for consideration in the future. The important point to be remembered is that embankments of any length are bound to be a very effective obstacle to free flow of flood water. Moreover, permanent embankments imply permanent bridges. For any one stream it would be quite insufficient to provide a single bridge just capable of carrying all the flood water brought down by the stream. Even though the bridge were built at the place where the stream happened to cross the line at the time, the river would be bound to keep on changing its channel until the whole of the low ground had been raised. Unless a number of other bridges of equal capacity were provided for its use from time to time, there would be serious danger of the line being breached. Moreover, it would be a fatal mistake to assume that the high flood level would remain the same after the stream had been confined to a single bridge as it was when the river

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THE MINHLA STREAM

68. Minhla *laha* and *thegaw*, photo from launch.

69. Minhla *thegaw*, leading channel, looking upstream.

70. Minhla *thegaw*, at upper end ; note escape of water to the right.

September, 1923. F. A. LEETE.

[*To face p.* 70.

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was allowed to flow freely wherever it liked. The flood level would certainly rise, and so the whole series of bridges together with the embankments would have to be correspondingly higher. How great the height ought to be would be extremely difficult to calculate beforehand, and so a liberal margin of safety would have to be provided. The point which it is desired to make is that the initial capital cost of such a road or railway, if the project were carried out on sound lines, would be far greater than in a tract where river channels are fully developed. If provision on this scale is not made in the original estimate, heavy expenditure in later years on the construction of additional bridges and on raising the level of existing bridges and embankments would have to be faced. Such extra expenditure would be a fair charge against the same head as the original project.

Carrying a road or railway across partially developed river channels should be avoided if possible. It would, as a rule, be preferable to face the additional expense involved in carrying the road or railway by a more roundabout route. Such a diversion need not be looked upon as permanent. After a longer or shorter term of years, the streams might be expected to have formed good channels beyond the original and more direct route; and proposals for permanent construction would then be quite in order.

Assuming, however, that the line must be carried across an undeveloped river, the only safe plan would seem to be to carry it on trestles. The stream could then continue to cross the line wherever it liked. It would silt up the trestles, first in one place and then in another, until ultimately it had formed a deep and permanent channel for itself. Then would be the time to give the deep stream a permanent bridge. The interval might be a long one. It might be as much as fifty years, during which time the trestles would have to be maintained. But even so it is believed that the cost of original construction *plus* maintenance and final construction would amount to a smaller sum than would be necessary if the line had been constructed with embankments and permanent bridges in the first instance.

107. Examples in Tharrawaddy.—(1) The Rangoon-Prome railway line was constructed about the year 1867. The only printed survey maps available for this part of the country are those of 1882. Comparison between the network of channels shown in the 1882 maps and the far smaller number of streams flowing across the railway to-day would probably convince any one that conditions throughout the northern half of the Tharrawaddy District in 1882 were not unlike the *laha* conditions described in this book. Such an impression would be confirmed by a perusal of the extracts from Gordon's Report on the Irrawaddy in 1879 reproduced in Chapter X. Paras. 113 to 118 show conclusively that when this Report was written *laha* conditions still existed close to the railway for several of the streams. The railway itself was constructed twelve years earlier. If the history of the line were written, it is believed that it would show a record of numerous breaches of the line by flooding and of frequent changes of the bridges. Stability has now been reached, except, perhaps, in respect of the size of some of the bridges from a logging point of view.

(2) In para. 3 mention has already been made of the construction of the embanked road from Paungde to Tapun in 1867 and its abandonment about 1903. The road was given up because the Taungnyo stream had no respect for it in its wanderings.

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(3) Many years ago an embanked and bridged footpath was constructed from Minhla, on the railway to Tanbingon, on the Myitmaka, to give access to the important town of Monyo, on the Irrawaddy. The writer's first acquaintance with this path was in 1914. At the lower end bridges had practically disappeared, and so had the pathway itself for something like two miles. The upkeep of the pathway was given up as hopeless about this time. From Map No. 9 it will be seen that a large part of the line is still in the *laha*, and a much greater portion must have been so when the pathway was first constructed. If a series of trestle bridges had been made, such as can be seen anywhere in the neighbourhood of towns and villages in Burma, the chances are that the pathway would have still been in use to-day, and that the annual bill for maintenance would not have been excessive.

(4) In para. 3 mention is made of the fact that the Bilin stream was embanked about the year 1882 from the P.W.D. road down to the railway bridge, to protect the road, the railway, and the town of Letpadan from flooding. It is also stated that these embankments were effective in putting an end to the trouble in their vicinity. This latter remark was true enough twenty years ago, but it needs some qualification now. The channel of the Bilin is by no means straight, and scouring of the banks on outer curves has gone on to such an extent that the bunds have been undermined in several places in the past ten years. Numerous breaches have occurred, and there has been constantly recurring expenditure on maintenance of the bunds. It is now seriously proposed to build new lines of embankments some distance behind the existing ones. Land will have to be acquired for the purpose. This sort of thing could not have happened if the Bilin had been helped to build up its banks without embankments forty years ago.

108. Examples in the Pegu District.—The history of railway construction and maintenance in the Pegu District, on the opposite side of the Pegu Yomas, affords striking testimony to the soundness of the deductions set forth in the opening paragraphs of this chapter. The story of the Yenwe Training Works is included, as these works were started for the sake of the railway.

The Rangoon-Toungoo part of the main line to Mandalay was built about the year 1883. As can be seen from Map No. 1 (facing page 1) and the enlarged outline map herewith, the railway line makes a big bend in the neighbourhood of Pyuntaza. The maps also show a road line which leaves the railway at Kadok (twenty-one miles south of Pyuntaza) and, running due north *viâ* Okshitgon for a distance of about forty-two miles, rejoins the railway at Penwegon (twenty-seven miles north of Pyuntaza). This is the old Pegu-Toungoo *minlan*, or military road line, the alignment of which dates back to the annexation of the Province of Pegu in 1852. It was laid out with broad curves with the idea that the railway would follow it. The latter idea fell through, and so also did road construction. The route actually taken by the railway was *viâ* Pyuntaza and Nyaunglebin. The writer has had no opportunity of finding out from old records how this change came about. It would probably not be far wrong to assume that cheaper bridging and more local traffic from the Sittang turned the scale.

In 1883 the section of the Yenwe at its exit from the hills twenty miles above Pyuntaza was in all probability much the same as it is to-day—namely, about

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November, 1923. F. A. LEETE.

THE MINHLA STREAM.

71. View of *thegaw* looking upstream from the same place as No. 69 two months later, small rise on ; note the strong flow owing to the *laha* having dropped over 10 feet.

January, 1924. F. A. LEETE.

THE MINHLA STREAM.

72. Same place as the above two months later ; *laha* quite dry ; note the excellent channel, 50 by 12 feet, scoured out of the *thegaw*.

[*To face p.* 72.

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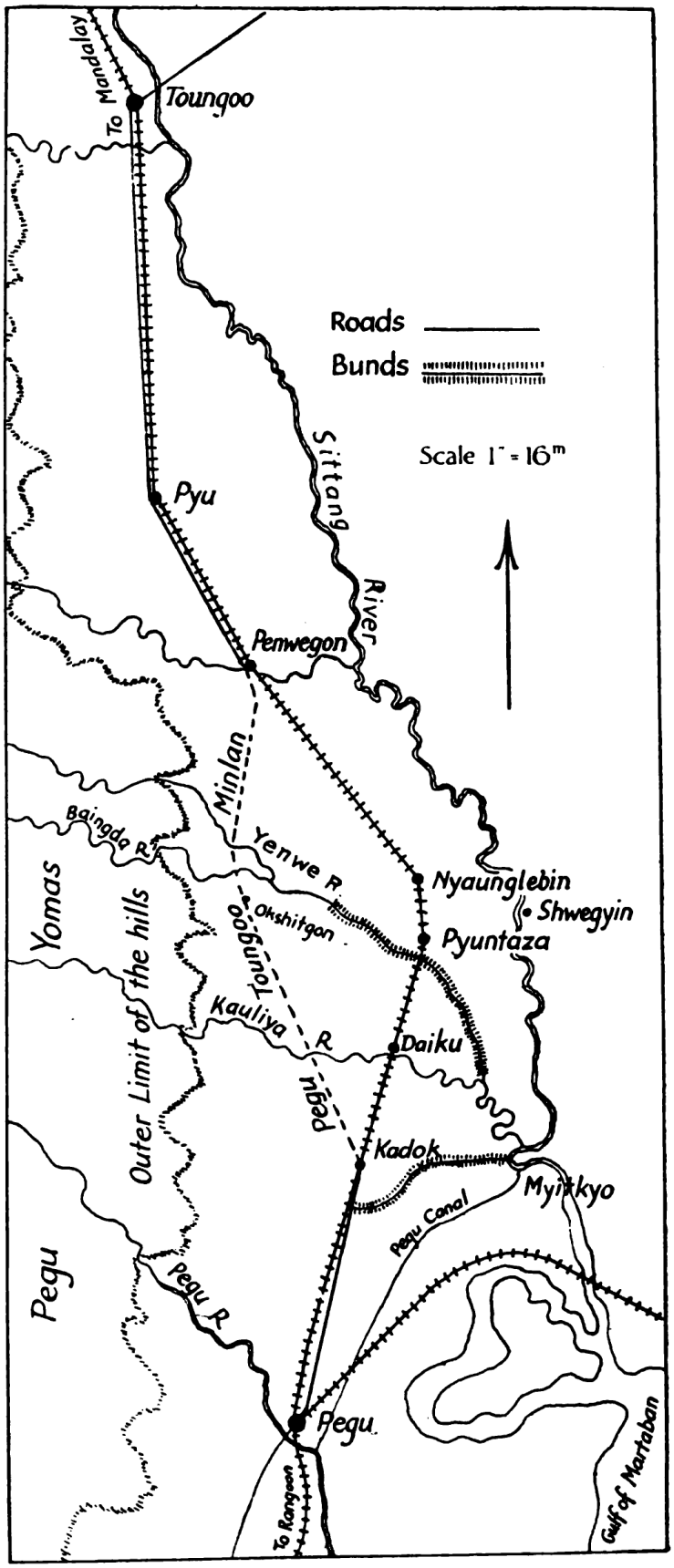
250 by 25 feet—for which an expensive single span bridge would have been required. But, forty years ago, the whole of the Pyuntaza plain was under what are referred to in this book as *laha* conditions. None of the hill streams had developed good channels far away from the hills. This may be inferred from the fact that thirty-three years after the railway was built—*i.e.*, in 1915—the good channel of the Yenwe ended five miles *above* Pyuntaza.

The picture presented by the Yenwe in 1883 was of a river which broke up into a series of constantly changing branched channels soon after leaving the hills. No one branch remained unchanged or deserved to be looked upon as the main channel for any length of time. All the sandy silt brought down from the hills was spread over the country in the immediate vicinity of this network of channels. Thereafter, the Yenwe flood water carried little or nothing but fine clay in suspension, and simply added to the general inundation of the plain caused by the heavy local rainfall of about 108 inches. Crossing the Pyuntaza railway alignment there was probably nothing but a number of shallow watercourses with mud banks, and comparatively inexpensive to bridge.



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109. Whatever may have been the saving on original construction by following the Pyuntaza route, it is well known that the maintenance of the line for some miles on both sides of Pyuntaza has been a constant source of anxiety and expense. Bridges have been raised or changed altogether several times, and the embankment has also been raised more than once. The very existence of the railway has been threatened by the Yenwe repeatedly. As recently as 1923 all traffic was suspended for three days, owing to floods having topped the embankment.

Training works on the Yenwe were started many years ago for the sake of the railway. What the bill up to date, for them and for alterations to the railway embankment and bridges, amounts to is not known, but it is believed to be not far short of £150,000 (22 lakhs of rupees). In spite of this large expenditure, the end is not yet in sight. The high-flood level at the Pyuntaza bridge has been steadily rising for many years past, and there is nothing to show that the maximum has yet been reached. Between 1910 and 1923 the flood level rose by 9 feet. The writer is not alone in the belief that it will rise several feet higher still. Seeing that the water touched the bridge girders in 1923, the prospect before the railway certainly does not look very cheerful.

110. Whatever view may be taken as to the soundness of the choice of the Pyuntaza route in 1883, it is evident that the railway engineers did not realise what they were up against. The Yenwe's annual output of 10,000,000 cubic yards of silt certainly did not enter into their calculations as being any concern of the railway. The inevitability of flood levels rising as the good channel travelled downstream was not taken into account. Most serious omission of all, the need for waterway far in excess of the requirements of the river as a single stream, was not visualised.

Attention is invited to para. 134 of Gordon's Report on the Irrawaddy in 1879. Referring to the proposed branch line across the Myitmaka valley to the Irrawaddy, opposite Henzada, Gordon voted for building the railway on trestles for a length of eight miles across the annually inundated part of the route (*laha*).

It is a remarkable fact that this plan was not followed near Pyuntaza when construction commenced four years later. It can only be inferred that the similarity of the two problems was not realised. The Pyuntaza problem was indeed the more difficult one and, therefore, called all the more strongly for trestle work. The Myitmaka had already formed a good channel for itself, but the Yenwe had not then done so, and the selection of a site for a single channel for the river was at that time an impossibility.

In the Yenwe Training Works themselves there is also matter for regret. They have all along been based on embankments. The stream has been double bunded for five miles above the railway and for nine miles below it. All the drawbacks to embankments indicated in previous paragraphs of this book have been conspicuously present, as, for example, high initial cost, heavy maintenance charges, and perpetual breaching. Security for the future has not yet been attained. A recent visit to the Yenwe has resulted in the firm conviction that training without embankments would have been far and away the soundest policy. Expenditure would have been far less, and infinitely greater stability both for the railway and for cultivation would have been reached by now.

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CHAPTER VIII

NOTES ON THE STREAMS

(The notes about the various streams in this chapter are intended to be supplementary to the remarks about particular parts of them in the other chapters)

THE SHWELE (Map No. 7)

111. In 1910 it was decided to abandon the river below the railway for the floating of timber in favour of extraction to Rangoon by rail. The history of the project and of the building and working of the Wegyi boom and depôt is dealt with elsewhere. Here it will suffice to mention that the depôt was in full work for two seasons, 1913 and 1914. In 1915 the boom was left open, and the depôt was closed as a temporary measure in order to see what could be done with the river under improved conditions. Results were so good that there was no further question of reopening the depôt, and it was accordingly dismantled. The forest rest-house there was pulled down and rebuilt at Tharrawaddy for the use of timber assistants.

Upper Section of the Stream.—The Shwele stream crosses the railway four miles from Paungde and, five miles further downstream, it passes under the Wetpok bridge of the Rangoon-Prome road. From the railway to the Myitmaka by the river is a distance of about eighteen miles. In recent years there have been four distinct parts or stages in the course of the stream. At the railway the river bed is about 150 by 15 feet. For about seven miles there is no appreciable diminution. In old records there are several references to channels having been dug for the Shwele in this part of its course.

In the next five miles, bringing us to the end of the first stage at Kywedegale, it was noticed in 1913 that there was a gradual decrease in width and height to about 60 by 10 feet. Down to this point the stream was distinctly good, and no great changes appear to have taken place for many years, although breaches and general flooding occurred from time to time. In 1915, as a result of activity in creek clearing, there was a marked increase in the size of the channel. It became nowhere less than 70 feet wide and in many places it was well over 100 feet. This rapid expansion was something of a touch-and-go business, owing to the narrowness of the artificial banks of the stream due to villagers' field bunds being placed so close to it. Retirements of these villagers' bunds had to be made here and there everywhere. One big breach occurred in the ninth mile at Nyaungatpin village by which 1,207 logs escaped into the paddy fields. In 1918 a big breach occurred in the tenth mile at Le-u-su. Both of these breaches eventually silted up and hardly any trace of them now remains.

112. Second Section, above Monywagyi.—The second stage is the mile and a half between Kywedegale and Monywagyi, fourteen miles from the railway. As already explained in para. 19, when the river first began to head

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in its present direction (between 1865 and 1875) it simply emptied itself into a huge swamp (Kya In) above Monywagyi. This swamp was practically continuous with the *laha* during the Rains, and so it was a simple matter to pole logs direct from it to the big depôt for Shwele and Taungnyo logs at Mindu on the Myitmaka, but, in the course of time, the river made the problem of extracting logs a much more difficult one. In a period of about forty years the river practically obliterated the central portion of this big swamp. During this time there must have been endless variations in the location of the main channel. How many logs were buried, who can say ? They might well be estimated at thousands. Map No. 4 (facing page 61) does not show anything like all the twists and turns which existed in 1913. Half-way between Kywedegale and Monywagyi the banks of the main channel were only 2 or 3 feet high. The river had for years received no attention whatever, and it never got a real chance to straighten or improve itself, owing to the thousands of logs, hundreds of snags, and tons of rubbish which it was expected to carry. The wonder is not that the stream was so bad so much as that it was able to make headway at all. That it would have improved if only it had been given a reasonable chance was illustrated in 1914. In 1913 and 1914, whilst the Wegyi depot project was in operation, logs were held up. This alone was sufficient to enable the stream above Monywagyi to develop banks from 4 to 6 feet high in a single season ; but even so, a number of sharp turns still remained, and when the Wegyi boom broke in October, 1914, the river was very badly upset. Over 1,600 logs escaped from the depôt, and they all stuck within half a mile of Kywedegale.

At Monywagyi there was a perceptible improvement in the stream in 1914. The channel was a good one, and remained so for some miles further downstream. The solution which suggested itself was to dig a canal from Kywedegale to Monywagyi and enclose it by high embankments capable of holding in all flood water. The project was highly successful, as described elsewhere in this book.

113. Third Section, down to Kywethe.—In 1915, when describing the river as it was in 1913, the third stage was said to be the three miles between Monywagyi and Kywethe, seventeen miles from the railway, where the ordinary *laha* then began. In the 1882 maps a cart track is shown where the river now runs. The *laha* at that time extended right up to Monywagyi. Old villagers still living remember the time when logs were collected in the Kya In until the Irrawaddy was high and then poled straight across country to the Myitmaka. The present channel only began to assume a permanent form some twenty years ago. The village of Kyundawgon is about this age. Kywethe itself is not more than fifteen years old. In 1913 the channel down to Kywethe was from 50 to 60 feet wide and from 6 to 8 feet deep. Being so much smaller than above Kywedegale, more flooding naturally occurred. Breaches were numerous, and a lot of logs went astray. The effect of the canal dug in 1915 above Monywagyi was to increase the average section to about 70 by 8 feet in a single season. At Gwegyi (two and a half miles below Monywagyi) there used to be a sharp bend which gave trouble to logs. A short-cut eliminating this bend was made in 1919. Photo No. 48 (facing page 50) shows the new channel. In 1913 the third stage of the river was said to end at Kywethe, because the good channel

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came to an abrupt end there. At Kywethe the main channel appears never to have been more than about 30 feet wide. In January, 1914, it was found completely blocked with rubbish and logs for a distance of a quarter of a mile. Unable to push this mass any further forward, the river had cut a new channel for itself down the middle of the village, joining the old one again a short distance further on, but for the next half a mile none of the various channels were anything more than mere ditches about 15 feet wide and a foot or so deep. They looked like ordinary cart-tracks more than anything else, and some of them were actually used as such.

114. Training Works in 1916.—The success of the embanked canal made above Monywagyi in 1915 naturally gave rise to the thought that it would be a good thing to extend the embankments in future years. Although Mr. Samuelson recommended this course for the Taungnyo at Tapun in 1916, he did not advise any embanking of the Shwele below Monywagyi because he was afraid of the effect on the Myitmaka of discharging Shwele silt direct into it. He advised leaving the channel below Monywagyi severely alone, doing nothing beyond levelling field bunds close to the channel and blocking up depressions—doing everything possible, in fact, to promote even flooding and general raising of the ground level in the vicinity of the stream. Expectations were realised in subsequent years. Cultivation has been extended in width on both banks, and the channel has increased in section. Moreover, what was the fourth stage of the river in 1915 has now been eliminated, because the good channel extends all the way down to the Myitmaka, and the ground in its immediate vicinity has already been raised sufficiently to make cultivation possible.

115. The *Laha* below Kywethe.—In 1914 the ordinary *laha* limit reached up to Kywethe. Half a mile lower down the small silted-up channel entered the Myitmaka, the latter having a section of 60 by 8 feet. In this section all that was done in 1915 was to remove obstructions and make a wide jungle clearing from Kywethe to the Myitmaka. A small leading channel 5 by 4 feet was dug through the *thegaw*. Results during the following Rains were on the whole good. The *thegaw* did move down a bit and the channel up to Kywethe resumed its old dimensions of about 40 by 4 feet. The Rains of 1915 gave even better results, although a certain amount of experience had to be bought.

When faced with a very unpleasant-looking mess after a heavy downpour in May, it was decided to revert to an old channel which led into the Myitmaka further upstream. With this object in view a small cut, 6 by 4 feet, was made to connect the Shwele with it. It was a sound plan. The river took kindly to this line and stuck to it all through the Rains that year. At the end of October, 1915, there was a good current right through to the Myitmaka, with nowhere less than 5 feet of water.

Present State of the Channel.—Two short cuts to eliminate bends were made in later years, but no necessity has arisen to think of making any further change in the course of the Shwele. A more detailed description of the present state of the lower part of the river is given in para. 82 of Chapter VI., relating to the Myitmaka itself. Although results have been so good, it must not be thought that the timber staff have had an easy time of it. Huge jams of logs

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and bad breaches of the banks similar to those described in the case of the Taungnyo stream frequently occurred between 1916 and 1921. They may occur at any time in the future if efforts are relaxed in respect of logging operations and the management of the stream generally.

THE TAUNGNYO (Map No. 7)

116. Early History.—The past history of the Taungnyo stream is full of interest. More has been written about this river than about all the others put together. It figures very largely in Gordon's Report in 1879, and again in Lieut.-Colonel Scott-Moncrieff's Note in 1882. Proposals for diverting it were put forward in 1895; embankment was suggested in 1903 and again in 1909.

The small maps referred to in para. 19 give a very good idea of the deltaic character of the stream right up to the hills sixty years ago. In Gordon's time, the stream had much the same course as it now has for the first seven miles from the railway. In the eighth mile it crossed the Paungde-Tapun road at Labagyin, flowing westwards under the name of the Teikpeik Chaung. Shortly after 1882, the stream commenced to take a new line from Labagyin southwards. The embanked road was evidently just as much an obstruction to the river as it proved to be thirty years later, three miles further downstream at Tagyo. By 1891 the stream had definitely taken to this new course. It flowed into the Uboksin Yo and spread broadcast over the countryside, burying whatever cultivation existed, under big deposits of sandy silt. The flood waters used to escape into the Tapun Chaung.

117. Size of the Channel.—At the railway the section is about 150 by 15 feet. There is no appreciable diminution as far as Upper Thakuttan, nine and a half miles down; then the width gradually decreases to 100 feet at Tagyo, eleven miles from the railway and at the end of the good channel in 1914. In 1909 the good channel ended at Thakuttan. A bird's-eye view of this section of the river would show it as a huge zig-zag, with two right-angled bends at Labagyin and Upper Thakuttan respectively. What it is here desired to bring out is that, although the part above Labagyin dates back over half a century, the central portion only began to form in 1881, and the lower part did not begin to assume its present permanent form until about 1909, or nearly fourteen years ago. To make for itself one and a half miles of channel 100 feet wide and 15 feet deep in four years (for it was as good as it is to-day in 1913) is a remarkable feat. As this has been accomplished partly by scouring into ancient clay deposits, but more by building up banks of the river's own contemporary sand deposits, it was only to be expected that sketch maps should show a great number of temporary and varying channels. All trace of most of them has disappeared. As to the number of logs that have been buried and lost, it is impossible even to guess—thousands probably.

The village of Thinbangon is now half a mile from the river. It suffered badly in 1913. A large volume of water escaped by the Pebin Yo, silted up half the bridge on the P.W.D. road, flowed up the east borrow pit as far as the village, then breached the road and cut straight down through the middle of the village, depositing twenty-one logs inside the fence, and then back to the old channel by the west borrow pit; further on the stream lost itself in paddy

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fields. This is given as an example of what was a common occurrence somewhere or other every year.

118. The Tagyo Channel in 1913.—To find a river of the dimensions already given coming to an abrupt end as such in the middle of an apparently level plain, and continuing simply as a kaleidoscopic network of insignificant channels (*vide* Map No. 5, facing page 61), would be remarkable anywhere, and the chances are that the cause of the change would not be far to seek. Such is the case in the second stage of the Taungnyo, extending from Tagyo to the junction with the Tapun Chaung, a short distance of only a mile and a half.

The cause of the trouble was the P.W.D. road from Paungde to Tapun. From about 1909, when the main stream began to head definitely to the south-west from Upper Thakuttan, it was badly held up by the road. Practically the whole of the latter from the bridge below Thinbangon to the Thinaing bridge was washed away by degrees, but until 1914 no attempt was made by the Forest Department to let the river go straight across. In 1911 and 1912, it did so pretty considerably at Tagyo, but nothing better could be thought of then than to block up the breach in the road and force the river back into its borrow pit channel and under the Thinaing bridge. The two right-angled turns and the smallness of the bridge are quite enough to account for everything that followed.

On November 3rd, 1913, a big flood occurred, bringing down a thousand logs or more. The Thinaing bridge was promptly blocked with logs and the borrow pit channel between the bridge and Tagyo filled up solid with rubbish and logs. The stream flooded over the whole length of this part of the road, but the main current drove straight ahead at Tagyo through a breach 100 by 5 feet, and formed a broad and well-defined channel for about a quarter of a mile. What with loss of energy here and there in side outlets and obstacles in the form of logs dropped by the flood in its own path, the force of the current soon spent itself, and there ceased to be anything worth calling a main channel at all.

119. Preliminary Training Works below Tagyo in 1914.—Although the problem set to local officers in 1914 appeared at first sight to be hopeless, yet the more it was studied the brighter the outlook became. It only appeared to be hopeless so long as the key to the puzzle was missing. Having discovered that in the road, the solution was obvious—viz., to help the river in its efforts to go straight across the road and then to carry it on to the Tapun stream. In 1914 nothing ambitious was attempted. The Thinaing channel and other outlets were blocked and a small through channel to the Tapun stream was enlarged to 10 by 4 feet. Stranded logs being plentiful, a few hundreds of them were strung out in lines about 400 feet apart on both sides of the channel from Tagyo downwards. It was hoped that these strings of logs would act as low bunds, and, by holding the water in for an extra foot or two, encourage silting on the banks and help with the scouring out of the canal.

Big Embankments in 1915.—The results in the Rains, 1914, were disappointing. The lines of logs did help to raise the banks a bit, but it was impossible to hold in all the water even in a moderate rise, and the old branch channels constantly kept bursting open again. A good many logs were passed through to Mindu, but the season closed with just as bad a network of channels

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as ever, and an even greater number of stranded logs. There was, however, no cause for despondency. The big channel down to Tagyo, and for some distance beyond it, did become better. The remedy that suggested itself was double bunding, the embankments being set well back from the channel with the idea that the river would raise the banks inside the bunds. The advice of an engineer was asked for and obtained. The bunds recommended by Mr. Samuelson were practically finished when the Rains began.

The upper half of the work consisted in putting embankments on either side of an existing and good channel. In the lower half there was no single good channel to start with, and so a straight canal was dug 100 feet wide lengthwise through the network of small channels.

120. Tapun Stream.—In Tapun village there are two bridges over a channel bearing the same name as the village itself. The stream used not to be a hill stream, but simply drained the adjoining plain to the east of the village. On leaving the village the stream turned to the south, and, after meandering about for some miles, eventually reached the Myitmaka at Mindu as a small and shallow channel.

When the Taungnyo stream abandoned the Teikpeik channel (about 1882), and headed in a southerly direction, the greater part of the flood water naturally found its way into the Tapun stream. From this time onwards the latter should be looked upon as having been appropriated by the Taungnyo. Having been called upon to carry immense quantities of silt, large numbers of logs, and all the various kinds of floating obstructions common to a hill stream, it is no wonder that the *régime* of the old channel was entirely altered.

Rains, 1913.—After the Rains of 1913 it was found to have a section of 50 by 5 feet at the junction with the largest of the network of Taungnyo channels, but it diminished in width to 25 feet and to a depth of only 1 or 2 feet, one and a half miles further down at Yonbingwe. For over half a mile it was blocked solid with logs and rubbish. At the upper end there was a huge accumulation of rubbish mixed with logs. Lower down, the bed was clean, and logs could have floated freely if the stream had been cleared. In one place a 37-foot log had been purposely wedged across as a bridge, holding up the logs behind. In another place the logs had jammed at a bad corner. All the logs were hauled out in the following dry season. Outlets were filled up to bank level, and one or two short cuts were made to eliminate bad bends. At Yonbingwe a canal 10 by 4 feet was dug through the *thegaw*. It was hoped that the river would wash itself out and improve with the first floods. Expectations were realised. Early in the Rains, 1914, a good current was set up, all the logs on the banks were sent down to Mindu and extra ones that came down from above. Later on in the season, when the *laha* was up, the *thegaw* reappeared in its old place, but even so it was not so bad as it was before.

121. Rains, 1915.—The object of the canal and big embankments already described was to lead the Taungnyo into the Tapun stream. It was hoped that the latter would thereby be enlarged and improved. In the earlier part of the Rains, it looked as though everything was going to remain good. As soon as the flood water reached the end of the embankments, it spread out all round and carried logs with it. Floating booms of logs were fixed up in extension of the embankments to let the surplus water pass off and yet hold in the

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logs. No bad jams occurred; logs all passed down the Tapun stream safely. This was at the beginning of the season. Later in the year, however, there was a change. The *laha* flood was exceptionally high in August and September, and reached almost up to the end of the embankments. The rise in September brought down a lot of logs, which jammed in the Tapun stream and caused it to silt up considerably. The passage through it was cleared, but the bed still remained shallow. In October the finishing touch was given. Rises of moderate height on the 13th and 24th of the month brought down something like 4,000 logs in a few hours. A huge jam of logs formed fanwise all round the end of the embankments and blocked up the Tapun channel for some distance.

Rains, 1916.—In Chapter VII. a description of the training works undertaken in 1916 is given—namely, the extension of the high embankments by low ones for a length of a mile. In the same chapter it is also explained that these low embankments were not extended in later years, as it was decided that we could do better without them altogether. In Chapter IV. some of Mr. Cheyne's experiences with breaches and jams of logs are described, and it now only remains to add his remarks about the channel itself and its present excellent condition.

122. Operations on the Taungnyo in 1917 (by Mr. Cheyne).—At the beginning of the floating season, 1917, from the end of the low bunds, for a distance of half a mile—that is, down to the bend above Yonbingwe—the first two rises scoured out a good channel 60 feet wide. After passing the big bend, there was still the same shallow, narrow and tortuous channel from Yonbingwe down to Yegyibauk, a quarter of a mile above Pongyiseik. From Yegyibauk to a couple of hundred yards below Pongyiseik the channel was decidedly better, and had a section of 50 feet by 4 to 5 feet. This was due to the overflow from the right bank of the stream below the end of the bunds, after depositing its silt in low country to the right, coming back to the old channel with a strong head of water and carrying little or no silt. Further down, however, the channel was narrow and shallow. Levels had been taken in the previous hot weather, from which we deduced that the channel was decidedly higher than the adjoining country, and, therefore, that it would be advisable to consider the question of taking a new line. The results were not, however, available in time for a move to be made in this direction in anticipation of the Rains, 1917.

The Ayokma Channel on the Taungnyo.—The death-blow to the played-out channel was dealt when some 100 logs partly waterlogged were launched by mistake at the end of May. The strong head of water and fast current carried these logs beyond Yonbingwe, where they all stuck in the middle of the channel. They were rolled to the bank as quickly as possible, but a succession of small rises failed altogether to remove the *thegaw*. Being faced with the prospect of a very unpleasant mess, it was decided to abandon the channel and to trust to the *laha* to take out the logs, some 3,500 in number, from hut No. 1 to Mindu.

It was no easy matter to decide on a new channel. The most likely route seemed to be to follow a depression leading into the swamps below Katan, but as the Shwele had already begun to empty its silt into the Myitmaka close to Mindu, it was thought to be dangerous to risk letting Taungnyo water in

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above this village. There was a strong tendency for water to break through to the left at the big bend above Yonbingwe and to flow along a narrow though well-defined depression extending right into the *laha*. The depression was, in many places, not wider than sufficient to take a boat, and was through dense *laha* jungle growth with many hairpin bends. Prospects of securing a good channel were none too bright, but it was believed that sufficient water to float logs could be secured. The use of this channel as a temporary measure seemed to be the only feasible alternative.

To open the mouth of the new channel it was necessary to dig a small canal some 50 feet long and 10 by 4 feet in section through the bank of the previous year's floating channel. The new channel was opened on July 6th, and floating through to the Myitmaka was immediately rendered possible. To improve matters further, the line was cleared of all jungle growth, including many large trees ; three short cuts of 50 feet, 45 feet and 60 feet respectively were dug to a depth of 5 feet, and the small depression itself was cleared of all roots as far as possible. This was rather difficult, as most of them were covered to a depth of a foot with water.

From hut No. 1—that is, where the new channel took off—down to the Ayokma swamp, a row of bamboo stakes was driven in 100 feet from each bank, with their tops 3 feet above ground level. All weak places and bad curves were protected by the fixing of log booms. From hut No. 4 down to the Myitmaka, a small depression was found, but very narrow and tortuous and densely covered with jungle. A clearing 15 feet wide was made (there was no time for anything more), and all logs available were poled through it.

Men had to be stationed every fifty yards to assist logs in negotiating the succession of bad bends. No great trouble was experienced until July 16th, when a very high rise brought down 2,000 logs, which formed a solid jam from the end of the low bunds down to hut No. 1. This jam was negotiated very quickly, but the bunds were breached in several places. Another rise on July 30th brought down 1,500 logs, which jammed in the same place as before. The channel silted up badly.

At the beginning of August there was a succession of log-bearing rises, giving no opportunity to get the channel properly cleared of logs or to get all the breaches patched up. Owing to want of staff, creek clearing in the hills was not done as well as could have been desired, with the result that enormous quantities of rubbish came down. The high floods also added to the trouble by saturating and undermining the banks, so that a good many trees fell in, and several of them came right down and added to the mountain of difficulties below Zibingwe. The rise on August 17th beat all previous records, the water reaching 17 feet 6 inches at the railway bridge. The flood brought down some 2,000 logs to add to the mess.

As previous jams had not been got rid of, there was no clear waterway, and the deteriorating effect of successive jams being cumulative, the *thegaw* had reached well within the low bunds, and the whole stream broke through the breach on the right. The outlook seemed very black indeed. The channel below had disappeared, and there seemed to be no hope of improvement until the breach had been blocked. How this was done has already been described in para. 43.

From August to October it was a continual struggle to get a clear channel

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through to No. 4 hut, and it reflects great credit on Ranger Aung Chin and his staff, in that he succeeded in having a channel with a good flow all the way down by the end of October. The problem which then faced us was the disposal of some 7,000 odd logs which were lying in hopeless confusion from the end of the low bunds down to hut No. 3. No further log-bearing rises were anticipated, so all breaches and side spills were blocked with earth bunds, and it was decided to try and float the logs down by a series of bamboo weirs. Work was commenced in the middle of November, but was held up by a rise on the 22nd of the month which destroyed all the weirs and further deteriorated the channel. It is satisfactory to note that some good was accomplished. Over 2,000 logs were passed across the *thegaw* and the channel was left at the end of the season in a much better state than was anticipated.

The *laha* in 1917 was disappointing, as it did not reach its normal level. Late in the season it only remained up for about three days, but during this time 2,000 logs were passed down to Mindu by the old channel. If we had had the help of a big *laha*, there is no doubt that the outturn into the Myitmaka would have been much greater.

123. The Taungnyo in 1918 and Later Years (by Mr. Cheyne).—The decision made in 1917 to change the line of the channel from hut No. 1 down to the Myitmaka at Ngapigo, about two miles below the old junction at Mindu, was a very wise one. The effect of the partial clearing of the track done during the Rains, 1917, and of the stake bunding on both sides, was that considerable deposits took place before the end of the season, and a distinct channel with good banks began to form.

Before the 1918 rainy season began, a bad bend in the fourteenth mile near hut No. 1 was eliminated by a short cut about a quarter of a mile long. The rainy season was exceptional. The *laha* rose very rapidly in May and, later on in August, the gauge reading at Mindu was slightly higher than the 1915 maximum, that year itself being a record one. The river required constant attention owing to the large number of logs that came down. It will suffice, however, to refer to the accounts given in paras. 45 and 46 of the way in which big jams of logs were broken up.

124. The Taungnyo from 1919 to 1923.—After the Rains, 1918, another bad bend in the fifteenth mile was eliminated by what is known as the Ayokma Cut about a quarter of a mile long, which was dug 12 by 4 feet in January, 1919. Since then no changes have been made in the line of the channel itself. Five rainy seasons have gone by and year by year the channel has improved both as regards width of bed and height of banks. The changes in the landscape which have taken place since the writer first visited Tapun in 1913 are remarkable, to say nothing of the stream itself. Cultivation then stopped absolutely at a line passing east and west through Zibingwe. From here onwards to the Myitmaka, there was nothing but jungle and swamps. To-day the picture is totally different. Cultivation extends as far as the eye can reach in all directions from Zibingwe. At Ayokma the width of the reclaimed area is not less than a quarter of a mile on each side of the channel, and right down to Ngapigo itself paddy has been planted and good crops have been obtained for the past two years.

Future Probabilities.—According to present indications, the Taungnyo

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channel may be expected to remain where it is for many years to come. Such good banks have been developed that the river is not likely to show any inclination to desert its present channel, provided that logging operations and the removal of obstructions continue to be managed on existing lines. Other considerations may, however, have to be taken into account. The Taungnyo stream already discharges large quantities of silt into the Myitmaka, and a glance at the map will show that a large area of low-lying land still remains to the east of the channel. If trouble arises in the Myitmaka, or if it is thought desirable to utilise more of the Taungnyo silt in reclaiming this low ground, the question of diverting the channel will come up. Mr. Cheyne has already given some thought to the matter. The raising of the ground alongside the present channel from Tapun downwards has caused a depression to develop carrying the drainage from Tapun village itself. This depression runs southwards to Baing, and then turns south-eastwards for a long distance, finally reaching the Myitmaka near Baudigon, at the upper end of the Mingyi Chaung (*vide* Map No. 6). If and when it is desired to make any change in the Taungnyo Mr. Cheyne suggests turning it into this depression somewhere near Baing. If this is done and proves to be successful, a large extension of reclamation on the left bank of the Myitmaka will result, as none of the Taungnyo silt will reach the Myitmaka until some years later.

THE BAWBIN (Map No. 6)

125. The Bawbin crosses the railway a mile south of Zigon Station. Its section is, if anything, rather larger than that of the Taungnyo. The lower part of the stream, where it joins the Myitmaka, has already been dealt with in Chapter VI. It only remains to give a few notes on the upper portion of the channel.

The extremely artificial character of the banks, owing to a succession of field bunds having been thrown up by villagers close to the edge of the stream, has already been mentioned in paras. 31 and 70. The banks in many places have the appearance of artificial embankments. The channel is, moreover, by no means straight. There are a number of bad bends where there is great danger of the high marginal banks being completely cut through. This has happened several times.

Breaches in 1918 and 1917. — In 1917 a big breach occurred at Lemyethna in the tenth mile. A few logs escaped. The breach was closed by an earth bund, and has not since then given any trouble. This is not the case, however, with the breach which occurred at Yetho in the twelfth mile on July 19th, 1918. The villagers first of all attempted to close the breach by an earth bund, which gave way at the next rise. Further attempts were made the same year without success. In 1919 it was decided not to attempt to close the breach, but to treat it as a sluice. This plan answered very well that year and for the next two seasons. A considerable amount of deposit was the result. In 1922 some of the villagers whose cultivation was immediately behind the sluice attempted to block it up altogether by an earth bund. This bund was breached, and the log boom itself did not hold, with the result that some 600 logs escaped. After the Rains were over the sluice defences were re-built and the boom was repaired. In 1923, everything went satisfactorily and there was no escape of

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logs. Considerable deposition of silt has taken place in the low country to the north of the breach.

THE MYOLE (Map No. 8)

126. 1913 and 1914.—The Myole crosses the railway midway between Gyobingauk and Okpo. Near the railway the channel is from 75 to 100 feet wide and from 10 to 12 feet deep. For the first five miles the channel is a good one, but gradually diminishes to about 50 by 6 feet. From Sisongon (two and a half miles from the railway) the 1882 maps are more or less useless. From Sisongon downwards remains of a network of temporary channels can still be traced. When the river was inspected early in 1914 it was found to have made a more or less permanent channel to within half a mile of Gyogon. Then the channel came to an abrupt end in a mass of logs, rubbish and sand. Below the main mass of logs and rubbish, for a distance of about 50 yards, the channel was completely filled up and a crop of paddy was taken off it. A channel 24 by 3 feet then reappeared passing right into the *laha* about a mile further on. The *laha* was about four miles wide. The channels through it were numerous and small for the most part. About two miles from the Myitmaka a well-defined channel (Mingalun Chaung) 30 by 3 feet appeared, increasing in size to 100 by 15 feet at the mouth.

The initial blocking-up of the channel at Gyogon year by year was undoubtedly due to the floating of timber. One reason, however, why the river was unable to make headway was because of the action of local people. An endless succession of fishery weirs used to be put up, and in a number of places bunds were thrown right across the channel, in order to stop the flow of water. Villagers naturally did not want the river to eat up their fields, and so tried to divert it on to others.

Early in 1914 some of the stranded logs were carted to Tetswe, but there was no time to clear the *thegaw*. The result was that the river could not push its way through. It filled up the channel for half a mile backwards with logs, rubbish and silt and then broke off to the right below Kywethe village and made for the *laha* in a southerly direction. Knowing that only a limited number of logs were left in the forest, and that fellings in the drainage of the Myole would cease for several years, it was decided not to attempt any bunding work in 1915. Attention was simply given to getting out the 2,000 odd logs left, partly in the forest and partly in the stream. This done, the stream could be left to itself for a time.

127. 1916 to 1918.—Mr. Cheyne's history of the stream since 1916 is as follows :—

At the end of the Rains, 1914, the Myole had a defined channel down to Kywethe in the fifth mile from the railway. In 1915 and 1916 very little was attempted. In 1917, the good channel had not progressed beyond the fifth mile and training works were started. All side-outlets were blocked by a series of strutted bamboo fences, and two rows of bamboo stake fences were put in, 100 feet on either side of the line along which it was proposed to lead the channel from Kywethe to Nyaungbinaing. Several cuts were made well inside the *laha* area, but these were all superfluous. It is an irrefutable axiom that successful stream training must progress from above downwards.

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Rains, 1919.—Early in 1919 a cut 1,720 feet long was made to eliminate the bad bend (AB) just above Nyaungbinaing. All stake fences above the new cut were repaired and continued on either side to the end of the Cut. The early rises of 1919 indicated what appeared to be a better line than the course *viâ* Mingalun. After careful inspection of the surrounding country had been made, it was found that there was a pronounced fall from Nyaungbinaing to Tawtanigon. Between Tawtanigon and the Myitmaka, a distance of just over a mile, there was a series of swamps. It was immediately decided to give this line a trial, and in July the water was diverted round the southern end of Nyaungbinaing village and kept along the new line by lateral stake fences.

By the end of the Rains well-defined banks had been secured down to Nyaungbinaing (mile eight), but below this the channel was narrow, shallow and tortuous.

Rains, 1920.—Early in 1920 a cut (CD) 3 furlongs long was made just above Tawtanigon. A jungle clearing 100 feet wide was made from Tawtanigon to Kabaunggon and two narrow cuts to connect the chain of swamps. The inevitable silting of the bed took place, but the table of cross-sections in Chapter IX. shows that the stream had improved considerably during the year.

Rains, 1921.—Early in the Rains of 1921 the channel improved considerably, but silted up solid to the top end of the 1921 cut in the ninth mile when the *laha* came up. It was decided to eliminate the bad bend between the eighth and ninth miles. This was done by putting rows of bamboo stakes 50 feet on either side of the new line. Several hundred small logs had been launched in the forest in the cold weather, and these proved invaluable when they arrived, as they were herring-boned on either side to keep the stream to the desired course. The channel was again obliterated when the *laha* came up, but by the end of the season there was a defined channel as far as Tawtanigon.

Rains, 1922 and Later.—The Myole stream has never been bunded. The present channel from Kywethe to Tawtanigon has been obtained entirely by means of short cuts to get rid of bad bends and by keeping the stream to the desired line by stake fencing. Reference is invited to para. 94 and to Photos Nos. 4 (Plate 3), 60 and 61 (Plate 31) dealing with the preparations for extending the good channel in 1924.

THE GAMON STREAM (Map No. 9)

128. 1913 to 1915.—The Gamon crosses the railway at Okpo Railway Station and runs for a long distance parallel to and about two miles away from the Myole. In point of size the Gamon is quite as large as the Taungnyo. For the first eight miles from the railway in 1914 the channel was from 70 to 100 feet wide and from 12 to 15 feet deep. Examination of the 1882 maps shows that the channel near Kinbungyun (seventh mile), although so good, is totally different to the one the river ran in forty years ago. For two miles below Kinbungyun in 1914 there was a very good channel which had been steadily improving in recent years, partly by scouring into the clay and partly by bank deposition. As proof of the latter, it may be mentioned that in April, 1915, a log 2 feet 6 inches in diameter was dug up within 50 yards of the bank above the upper end of Letpanyegyaw village. The hammer marks on the log showed that it

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could not have come down from the forests before 1910 or 1911. It was lying flat and practically covered over by deposits. The banks here were, therefore, nearly 3 feet higher than they were four or five years previously.

Just after the Rains, 1914, the good channel came to an abrupt end at the lower end of the new village of Letpanyegyaw. The section suddenly dropped from 50 by 11 feet to 50 by 3 feet, and continued so for half a mile, choked up with logs, snags, rubbish and sand. From there onwards in the *laha* the channel remained small (about 15 by 3 feet) for about three miles.

The obstructions at the *thegaw* were not removed before the Rains began in 1914. The result was that the river took a new line for itself, although the improvement of the old channel above the breach continued; the section enlarged itself both in width and depth.

Construction of embankments on other streams took up so much time that it was out of the question to make any on the Gamon in 1915. As noted in para. 90, and illustrated in Photos Nos. 56 and 57 (Plate 29), a leading channel was dug and rows of bamboo stakes were placed along both sides of it. Results were remarkably good. The good channel of the stream was extended downstream for three-quarters of a mile.

129. 1916 and Later Years.—From the end of the good channel in 1915 down to the Myitmaka, the Gamon has a length of about six miles. Midway between miles twelve and thirteen, near Kyetsha, it is joined by the Minhla stream. From the junction to the Myitmaka at Tanbingon by the channel in the *laha* is a distance of about three miles.

In the eight years, 1916 to 1923, there has been steady progress in the improvement of the channel. At the end of Rains, 1923, the *thegaw* was close to the Minhla junction in the thirteenth mile. The table of cross-sections in Chapter IX. shows clearly how the good channel has been extended. During this period of eight years nothing has been done beyond stake fencing and the clearing of small leading channels to eliminate bad bends. The *laha* has been pushed back fully three miles. When the writer was at Letpanyegyaw village in 1914 it consisted of only two or three huts. Looking downstream no cultivation whatever was visible; it was all jungle and *kaing* grass. In 1915 a remarkable change in the picture had taken place. There were a hundred houses in the village, and a strip of cultivation could be seen extending as far as the eye could reach downstream on both the banks. The story has continued on similar lines in subsequent years.

MINHLA STREAM (Map No. 9)

130. 1913 to 1915.—The Minhla stream crosses the railway about a mile and a half north of the Minhla Railway Station. The section at the railway is about 100 by 8 feet, and for the first two miles there was no appreciable diminution in 1914. In the next three miles the following changes took place in the three years 1913 to 1915:—

After the Rains, 1913, between Seinbu and Kayin-ta-ain (three miles from the railway) the section was 75 by 7 feet and the first sign of flooding was apparent. At one place the stream undermined the paddy-field bund which was more or less continuous along the right bank. A good deal of silt was deposited in the paddy fields, and some logs were thrown up. A little further

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on the section was only 55 by 6 feet. About three-quarters of a mile beyond Kayin-ta-ain came the second place where the river overflowed in force, carrying silt and logs with it. A short distance further on the *thegaw* began and, it might almost have been said, the river ended. It would be more correct, however, to state that the 50 by 5 feet channel was completely blocked up for a length of about 400 feet, and then reappeared again as 15 by 3 feet, gradually increasing in size to 35 by 5 feet in the course of the next mile.

In 1914 nothing was done to help the stream, and the season closed with an even bigger *thegaw*. Down to the *thegaw* logs used to give no particular trouble. Across it logs had to be dragged by elephants for a distance of about a mile right into the *laha*, at an estimated cost of Rs. 2 (2*s*. 8*d*.) per log. The problem local officers set themselves to solve in 1915 was to see if the need for elephants could not be reduced, if not done away with altogether. The *thegaw* was dug for a length of about quarter of a mile, and a straight canal in continuation of it for a length of twenty-six chains, ignoring the old tortuous channel. Starting from the lower end of this canal, the channel was double-bunded for a little over two miles. New bunds for the whole length were not thought to be necessary ; for the most part paddy-field bunds already existed, and it was only a case of straightening them and making them continuous. After the canal as above had been dug it was extended for a little over 200 yards without bunds right into a big depression or buffalo wallow known as Tonbinaing. The results in the Rains, 1915, were remarkably good. The outturn of logs beat all previous records and there was no need to make use of elephants at all. Large deposits of silt took place all round the ends of the embankments, and the buffalo wallow vanished altogether.

131. 1916 and Later Years.—There is very little on record as to what happened in the years 1916 to 1918. Very little trouble with logs appears to have occurred until 1918, when a bad breach occurred in the right bank bund just below the fourth mile post. This breach was directly attributable to the stream having been somewhat neglected. Full attention had not been paid to the removal of floating obstructions. The breach in question may serve to point the moral that these streams cannot be neglected at any time with impunity. The breach was converted into a sluice in the same manner as the one which occurred the year before on the Taungnyo, described in paras. 43 and 44. By the end of the Rains, 1921, the sluice had completely silted up. In the interval a large area of low-lying land to the north had been reclaimed by the huge quantities of silt which passed through the sluice.

In the Rains, 1922, just at the time when the *thegaw* was at its worst, a rise occurred, bringing down some 4,000 logs, and a breach occurred in the left bund almost exactly opposite the 1917 one, which, as remarked above, had been completely closed by deposits. The logs formed a solid jam nearly a mile long in the channel from the *thegaw* upwards. It speaks well for the skill with which the logging operations are conducted that this huge jam was soon disposed of—again, be it noted, without the use of elephants. By the end of the Rains the channel was quite clear right into the *laha*.

Preparatory to the Rains, 1923, a boom was placed across the mouth of the breach in the left bund and it was converted into a sluice in the usual manner. Two additional sluices were also made in the right bund. The

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deposits which took place during the Rains, 1923, outside these sluices were remarkable.

The state of the Minhla stream in 1923 has already been described in Chapter VII. (para. 97 *et seq.*). All that need be noted here is that the remarkably fine channel shown in the photographs has been built up by the river itself from its own deposits. The straightness of the channel is simply due to the skilled attention of Mr. Cheyne and the men under him. Breaches close to the end of the good channel are only to be expected, but half a mile back they are a practical impossibility. The case, is, however, different in the part of the channel still enclosed by the embankments of 1915. Soon after they were constructed the opinion was formed that they were too close together. This view was confirmed by the breaches which subsequently occurred. It would certainly have paid to have demolished the embankments in 1917. They still, however, remain without serving any useful purpose. It is for consideration whether it would not be a good plan to dress them down.

THE MOKKA STREAM (Map No. 9)

132. The Mokka crosses the railway two and a half miles south of the Minhla Railway Station. In 1915 the *thegaw* was about seven miles from the railway, at the entrance to a big swamp known as the Bwetgyi-In. The stream used to lose itself in this swamp and then to reappear at the south-western end of the latter as a well-defined channel flowing southwards for a distance of seven miles to the Myitmaka at Alangon. In 1919 a short cut was made joining the channel above the swamp with that below it. The swamp itself had practically been silted up entirely. In 1922 another short cut was made to eliminate a big bend in the eighth mile. The stream itself has given very little trouble, but a certain amount of friction has occurred with the local people. They now so well realise what the effect of our Training Works is likely to be that they have taken to squatting on land in the *laha* whilst it is still covered with dense jungle and annually inundated with flood water to a depth of several feet. They realise well enough that in a few years this land will be covered with rich alluvial deposits and be raised above the level of serious flooding. In order to ensure that the Training Works are not hampered by action of this kind on the part of squatters, steps are being taken to acquire a strip of land along both banks of this and other streams.

THE BILIN STREAM (Map No. 10)

133. The Bilin stream crosses the railway one and a half miles south of the town of Letpadan, and has a well-defined, though tortuous, channel throughout its length of seven miles to the Myitmaka. Remarks have already been made in para. 107 with regard to embankments which were made about the year 1882. Owing to annually recurring trouble with these embankments, it may well be surmised that P.W.D. engineers would gladly do without the embankments at all if it were practicable.

Downstream from the end of the bunds to the Myitmaka the section is large

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enough to carry the highest jungle floods when the Irrawaddy is low, but there is an overflow in several places when the *laha* is high. Every year overflow takes place from about the sixth mile from the railway bridge. When this occurs, no logs reach the Myitmaka direct, as they are carried by the *laha* current in a southerly direction. There is annually recurring silting up of the channel when the *laha* is high and subsequent scouring of it out when the *laha* falls. There are no signs whatever of any permanent deterioration of the channel.

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CHAPTER IX

STATISTICAL DATA.

1. Table of Distances on the Myitmaka

(Measured along the Stream.)

	Miles.	
Inma Lake (centre) to Payadu	20	
Payadu to Mindu	3	25
Mindu to Ngapigo	2	
Ngapigo to Kwethe Yo	3	
Kwethe Yo to Baudigon	7	10
Baudigon to Bawbin (N. Myaung)	3	
N. Myaung to Bithalun	9	12
Bithalun to Tetswe	6	
Tetswe to Hmetkadan	5	11
Hmetkadan to Tanbingon	7	
Tanbingon to Shwelaung (Teindaw)	6	13
Shwelaung to Gamonseik (B. Rs.)	17	17
Gamonseik to Bilin	27	
Bilin to Sanywe (Thonze)	10	37
Sanywe to Nyaungwaing	70	
Nyaungwaing to Rangoon	15	85
Total		210

2. Rainfall

Rainfall is markedly heavier on the eastern slopes of the Pegu Yomas than it is on the western side. No rainfall records exist for the mountain range itself. Those maintained at various stations on the Rangoon-Prome railway show progressive variations from 120 inches at Rangoon to 100 inches at Tharrawaddy, and 50 or 60 inches at Prome.

The monsoon period usually lasts from the middle of May to the end of October. November is generally wet for a week or two, and a few days' rain in December is not unusual. Violent thunderstorms are not infrequent in March and April.

The record of log-bearing rises given in the next table is by no means a complete list of all the occasions when the Taungnyo stream came down in flood. Only rises bearing logs are entered.

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3. Log-bearing Rises in the Taungnyo Stream

Month.	1918.			1919.			1920.			1921.			1922.		
	Date.	Gauge.	Logs.	Date.	Gauge.	Logs.	Date.	Gauge.	Logs.	Date.	Gauge.	Logs.	Date.	Gauge.	Logs.
		Ft. In.			Ft. In.			Ft. In.			Ft. In.			Ft. In.	
May .	25	7 0	700	—	—	—	23	10 4	3,500	—	—	—	—	—	—
	26	7 10	2,000	—	—	—	29	6 1	200	—	—	—	—	—	—
June .	20	5 4	2,000	7	4 6	250	—	—	—	—	—	—	—	—	—
	24	5 4	30	20	6 2	700	—	—	—	—	—	—	—	—	—
	—	—	—	29	6 6	600	—	—	—	—	—	—	—	—	—
July .	16	5 6	1,200	7	6 4	250	3	7 0	1,500	8	7 0	1,100	8	6 0	900
	27	6 7	1,700	11	8 2	1,600	15	9 4	4,900	10	9 0	7,000	24	6 0	550
	29	7 10	1,700	12	7 6	400	—	—	—	27	7 9	1,400	27	8 3	1,700
	—	—	—	24	4 6	50	—	—	—	—	—	—	29	7 3	650
	—	—	—	26	5 6	550	—	—	—	—	—	—	—	—	—
	—	—	—	30	6 6	650	—	—	—	—	—	—	30		
	—	—	—	31	8 6	4,700	—	—	—	—	—	—	to	9 0	9,500
Aug. .	8	5 6	30	8	7 0	100	1	6 6	700	2	9 5	2,900	3	—	—
	9	6 6	600	15	7 0	100	2	6 5	650	6	8 6	1,300	7	8 0	700
	11	6 7	350	16	7 8	200	9	6 0	600	8	7 10	900	9	7 0	600
	13	8 0	1,600	26	6 8	500	21	8 0	500	13	6 9	400	10	9 3	1,600
	28	6 7	200	28	7 0	500	23	7 2	550	14	9 6	1,400	15	6 0	350
	—	—	—	30	7 2	300	31	7 9	700	18	7 0	600	25	6 9	420
	—	—	—	—	—	—	—	—	—	21	9 6	2,300	27	8 0	1,100
										25	7 0	620	31	7 6	400
	—	—	—	—	—	—	—	—	—	27	8 0	400	—	—	—
	—	—	—	—	—	—	—	—	—	28	9 7	900	—	—	—
	—	—	—	—	—	—	—	—	—	30	7 3	500	—	—	—
	—	—	—	—	—	—	—	—	—	31	6 6	300	—	—	—
Sept. .	3	8 0	600	5	6 8	400	6	9 4	700	—	—	—	4	8 6	700
	7	6 6	250	6	6 8	239	9	6 10	300	—	—	—	6		
	8	7 0	25	—	—	—	11	7 6	400	—	—	—	7	8 6	900
	9	7 1	1,000	—	—	—	18	8 0	750	—	—	—	—	—	—
	10	7 6	2,000	—	—	—	24	7 10	600	—	—	—	—	—	—
	27	7 6	150	—	—	—	—	—	—	—	—	—	—	—	—
Oct. .	8	6 6	150	—	—	—	4	6 6	80	—	—	—	—	—	—
	20	5 6	25	—	—	—	17	6 10	20	—	—	—	—	—	—
Other small rises.						—	—	—	358	—	—	695	—	—	755
Total	—	—	16,310	—	—	12,089	—	—	17,008	—	—	22,715	—	—	20,825

Measurements taken at the Zibingwe gauge.

4. Cross Sections of Streams

(a) *Shwele (Wetpok to Katan) in* 1922

Miles from Railway.	B.	D.	Remarks.	Miles from Railway.	B.	D.	Remarks.
	Ft.	Ft. In.			Ft.	Ft. In.	
0	130	16 8	Wetpok	8	78	12 6	—
1	126	13 3	—	9	86	8 4	—
2	108	13 8	—	10	101	7 7	—
3	118	12 9	—	11	58	7 6	—
4	119	12 0	—	12	58	7 3	—
5	97	13 2	—	13	50	7 0	—
6	117	12 7	—	14	61	6 0	—
7	94	13 6	—	15	60	9 0	—
—	—	—	—	16	80	9 0	Katan

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(*b*) *Taungnyo (Zibingwe to Ngapigo)*

Cross Section No.	Distance.	1917.		1918.		1919.		1920.		1921.		1922.		Remarks.
		B.	D.	B.	D.	B.	D.	B.	D.	B.	D.	B.	D.	
	Ft.	Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.	
1	0	188	5 0	191	7 2	192	6 8	192	9 4	156	7 10	150	8 1	Zibingwe.
2	1,000	91	6 10	101	7 6	101	7 10	103	8 5	100	8 10	131	8 10	
3	2,000	94	6 4	100	7 9	124	7 0	103	8 0	99	9 8	112	8 9	
4	3,000	112	5 6	132	6 8	124	7 3	121	7 6	119	8 0	116	8 6	
5	4,000	128	2 0	131	6 2	168	8 0	119	8 0	110	8 0	98	9 2	
6	5,000	114	3 6	157	5 9	108	8 3	127	8 7	128	8 4	127	9 0	
7	6,000	40	4 0	81	7 1	86	8 0	86	8 6	83	8 6	88	9 9	
8	7,000	25	3 4	77	7 2	89	8 3	76	9 6	76	11 0	71	10 3	
9	8,000	20	3 6	60	4 1	111	7 6	77	9 8	73	10 10	71	9 4	
10	9,000	20	3 6	46	5 5	93	9 2	67	8 3	59	8 6	77	9 3	
11	10,000	—	—	37	3 3	74	7 11	78	9 5	68	7 8	82	9 8	
12	11,000	—	—	31	2 6	79	7 0	65	8 5	60	8 10	63	9 0	
13	12,000	—	—	39	1 10	72	6 6	61	7 7	60	9 10	57	8 10	
14	13,000	—	—	36	1 10	79	6 0	52	7 0	57	9 3	50	8 2	
15	14,000	—	—	—	—	57	5 7	53	7 6	61	8 3	65	9 2	
16	15,000	—	—	—	—	61	4 7	36	6 9	43	8 2	40	8 1	
17	16,000	—	—	—	—	49	4 6	59	7 0	72	5 3	57	7 0	
18	17,000	—	—	—	—	67	7 6	51	6 9	78	3 6	63	8 5	
19	18,000	—	—	—	—	28	4 2	90	5 6	75	3 1	62	8 0	
20	19,000	—	—	—	—	13	4 0	105	4 11	74	2 8	63	8 1	
21	20,000	—	—	—	—	19	3 6	97	5 5	47	3 6	69	9 0	
22	21,000	—	—	—	—	—	—	—	—	93	6 10	33	8 5	
23	22,000	—	—	—	—	—	—	—	—	—	—	83	7 0	
	—	—	—	—	—	—	—	—	—	—	—	90	10 11	Ngapigo.

The measurements were taken after the rains in the years named.

(*c*) *Myole Stream (from Kywede to Tawtanigon)*

No.	Distance.	1918.		1919.		1920.		1921.		1922.	
		B.	D.	B.	D.	B.	D.	B.	D.	B.	D.
		Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.
1	0 Fr. (5)	74	8 4	74	6 9	74	8 0	75	8 6	69	11 10
3	2 ,, .	68	6 0	66	6 8	68	7 0	67	7 0	65	9 9
5	4 ,, .	62	5 9	67	6 7	68	6 10	68	6 11	70	10 0
7	6 ,, .	48	6 8	53	6 7	53	6 11	54	6 8	49	10 0
9	8 ,, (6).	36	5 6	42	6 10	42	7 0	43	7 3	60	9 6
11	10 ,, .	78	5 1	86	4 9	86	5 6	87	6 0	48	9 3
13	12 ,, .	42	4 6	47	5 9	47	6 4	47	6 0	48	7 8
15	14 ,, .	40	4 6	44	5 1	44	5 10	45	5 8	40	7 2
17	16 ,, (7).	42	4 4	44	4 9	46	5 9	46	5 10	48	7 6
19	18 ,, .	25	1 0	50	4 6	50	4 10	51	5 0	60	6 11
21	20 ,, .	25	0 6	39	4 1	39	4 6	40	4 8	43	6 7
23	22 ,, .	6	0 7	28	4 2	28	4 11	31	4 6	44	6 4
25	24 ,, (8).	43	3 5	42	2 11	42	3 0	47	3 4	49	6 8
27	26 ,, .	—	—	—	—	30	3 11	38	4 8	51	6 3
29	28 ,, .	—	—	—	—	22	3 9	34	4 1	39	6 4
31	30 ,, .	—	—	—	—	15	0 6	31	4 0	40	6 5
33	32 ,, (9).	—	—	—	—	15	1 0	23	3 3	38	5 11
35	34 ,, .	—	—	—	—	18	2 6	26	2 7	29	4 3

Miles from railway . . . . (5); Furlongs—Fr.

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(*d*) *Gamon Stream* (*from Post No.* 1 (*Tenth Mile*) *to Post No.* 21 Kyetsha)

No.	Distance.	1917.		1918.		1919.		1920.		1921.		1922.	
		B.	D.	B.	D.	B.	D.	B.	D.	B.	D.	B.	D.
		Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.
1	0 Fr. (10)	68	9 6	68	9 6	68	11 4	66	11 11	61	11 11	80	13 6
3	2 ,, .	68	17 0	68	17 0	77	16 0	69	17 0	71	15 6	70	13 0
5	4 ,, .	75	12 0	75	12 0	75	11 5	73	12 0	71	12 2	95	11 6
7	6 ,, .	97	10 4	97	10 4	95	11 6	63	10 4	71	13 2	92	10 0
9	8 ,, (11)	77	9 2	77	9 2	77	11 0	76	11 5	64	11 7	100	8 8
11	10 ,, .	65	6 0	65	6 0	91	9 6	86	8 3	70	9 4	70	8 5
13	12 ,, .	28	4 9	28	4 9	61	2 0	49	11 6	55	10 4	89	7 8
15	14 ,, .	28	5 0	28	5 0	34	1 6	30	2 11	80	9 5	48	7 7
17	16 ,, (12)	—	—	—	—	—	—	—	—	113	11 2	49	7 0
19	18 ,, .	—	—	—	—	—	—	—	—	80	6 0	32	6 0
21	20 ,, .	—	—	—	—	—	—	—	—	—	—	41	6 4

(*e*) *Minhla Stream* (*from Seinbu to Sunza*)

No.	Distance.	1919.		1920.		1921.		1922.	
		B.	D.	B.	D.	B.	D.	B.	D.
		Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.	Ft.	Ft. In.
1	0 Fr. (3).	94	10 6	97	10 6	97	12 0	120	10 6
3	2 ,, .	87	9 2	110	4 9	104	7 0	103	9 3
5	4 ,, .	81	9 2	86	9 3	87	9 5	100	9 8
7	6 ,, .	108	11 4	94	9 6	83	9 0	110	10 9
9	8 ,, (4).	98	8 5	103	9 6	103	8 10	101	9 6
11	10 ,, .	70	7 3	88	8 6	78	8 8	111	8 8
13	12 ,, .	90	6 10	110	7 8	94	8 0	81	8 0
15	14 ,, .	92	6 7	78	7 2	62	7 4	70	7 9
17	16 ,, (5).	76	6 7	53	7 7	53	7 7	63	7 8
19	18 ,, .	81	6 1	50	6 0	58	7 0	52	7 9
21	20 ,, .	94	6 9	73	4 6	66	5 5	35	6 4
23	22 ,, .	46	2 1	50	2 6	80	5 0	47	8 6
25	24 ,, (6).	—	—	38	4 2	42	5 8	30	10 2
27	26 ,, .	—	—	18	5 0	73	6 8	35	11 2
29	28 ,, .	—	—	—	—	16	3 6	43	8 8

Miles from railway . . . . . (3).

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(f) Mingyi Chaung (from Baudigon to Bithalun)

No.	1920. B.	1920. D.	1921. B.	1921. D.	Distance.		Remarks.
	Ft.	Ft. In.	Ft.	Ft. In.	Miles.	Feet.	
1	136	6 3	152	6 0	—	100	Opposite gauge post.
2	120	7 4	120	7 6	½	—	
3	87	9 10	87	10 0	1	—	
4	138	9 6	138	9 10	1½	—	
5	98	7 0	98	7 6	1	3,320	
6	103	6 10	103	7 0	2	—	
7	100	9 4	100	9 10	2	840	
8	114	3 8	115	3 6	2½	—	
9	200	8 3	200	8 0	3	—	
—	230	25 0	230	27 0	—	—	Near mouth of N. Myaung
10	182	9 6	182	8 0	3½	—	
11	155	9 7	157	8 10	3	4,690	
12	167	12 0	170	8 6	4	—	
13	170	9 2	171	8 8	4	1,060	
14	160	7 9	161	8 7	4½	—	Opposite Myauklokon.
15	155	7 5	157	8 10	5	—	Opposite Taungzalekon.
16	130	6 4	135	7 11	5	1,625	Below Taungzalekon.
17	140	6 7	142	7 6	5½	—	
18	165	6 3	166	8 2	5	4,660	
19	147	7 4	149	8 6	6	—	
20	220	8 2	220	8 6	6½	—	
21	140	9 11	143	10 11	7	—	
22	100	9 11	101	10 10	7½	—	
23	190	14 11	193	25 10	8	—	Ngagyi.
24	110	7 11	113	12 6	8½	—	
25	610	16 7	600	14 8	9	—	
26	434	14 9	430	14 6	9½	—	
27	600	15 5	598	14 4	10	—	Across Tanbingon Lake.
28	622	14 10	625	13 6	10½	—	
29	757	15 8	754	13 4	11	—	
30	251	14 11	400	14 6	11½	—	
31	65	14 7	65	14 9	12	2,940	Opposite Bithalun.

5. Outturn of Logs

(a) Receipts at the Sanywe Depôt

Year.	Shwele.	Taungnyo.	Bawbin.	Myole.	Gamon.	Minhla.	Mokka.	Bilin.	Thonze.	Total.
1907	1,970	4,603	2,842	—	1,531	869	18	2,262	933	15,028
1908	819	2,857	4,567	—	1,159	820	419	1,235	282	12,158
1909	625	2,817	4,931	—	1,008	686	200	2,831	904	14,002
1910	356	4,270	3,124	—	334	742	371	1,810	555	11,562
1911	102	2,048	2,632	—	3,531	845	577	2,247	1,399	13,381
1912	4	1,151	2,540	—	2,410	531	519	1,820	1,213	10,188
1913	3	431	3,462	—	575	752	833	2,652	2,765	11,473
1914	999	4,214	4,234	297	625	1,052	1,505	2,445	405	15,776
Total	4,878	22,391	28,332	297	11,173	6,297	4,442	17,302	8,456	103,568
Average	610	2,799	3,541	37	1,397	787	555	2,163	1,057	12,946

To the Shwele figures the number of logs hauled out at the Wegyi depôt whilst it was in working should be added, viz., 1911 and 1912, 4,241 logs ; 1913, 4,944 ; 1914, 7,234 logs ; total, 16,419 logs.

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(*b*) *Deliveries at all Depôts in the Myitmaka*

Year.	Shwele.	Taungnyo.	Bawbin.	Myole.	Gamon.	Minhla.	Mokka.	Bilin.	Thonze.	Total.
1915	9,146	10,755	8,943	1,669	3,465	1,079	—	1,565	2,203	38,825
1916	7,912	14,068	13,081	562	2,831	1,162	—	3,810	1,662	45,088
1917	12,131	12,251	11,632	—	3,453	1,539	531	3,520	1,649	46,706
1918	14,724	16,212	14,004	623	6,274	2,032	338	3,491	3,502	61,200
1919	9,753	15,811	11,407	122	4,519	2,591	1,599	2,427	2,039	50,268
1920	10,533	17,005	8,987	—	4,026	5,039	1,182	1,799	1,434	50,005
1921	21,551	22,715	14,650	583	8,122	4,987	2,080	3,343	2,335	80,366
1922	11,501	20,825	10,809	1,425	11,759	7,934	3,195	5,912	1,342	74,702
Total	97,251	129,642	93,513	4,984	44,449	26,363	8,925	25,867	16,166	447,160
Average	12,156	16,205	11,689	623	5,556	3,295	1,116	3,234	2,021	55,895

6. Expenditure on Logging and River Training Works

Year.		Shwele.	Taungnyo.	Bawbin.	Myole.	Gamon.	Minhla.	Mokka.	Bilin.	Thonze.	Total.
		Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
1915		33,687	102,783	49,971	3,742	6,738	11,638	—	—	—	208,559
1916		18,190	29,680	6,327	4,658	5,224	1,864	1,469	—	—	67,412
1917		10,799	26,299	10,858	4,982	4,078	4,191	—	—	—	61,207
1918		9,069	23,696	6,315	9,483	3,614	2,989	9	—	—	55,175
1919		6,356	9,597	5,423	6,423	3,316	2,857	1,179	—	—	35,151
1920		6,087	11,351	2,586	6,937	2,543	2,785	979	—	—	33,268
1921		3,959	6,396	3,612	4,318	2,092	3,711	3,398	—	—	27,486
1922		5,031	5,472	3,783	5,607	3,084	4,564	3,061	—	—	30,602
Total	Rs.	93,178	215,274	88,875	46,150	30,689	34,599	10,095	—	—	518,860
	£	6,212	14,352	5,925	3,077	2,046	2,306	673	—	—	34,591

The above figures only include expenditure incurred between the railway and depôts in the Myitmaka. The cost of creek clearing (para. 55) above the railway in the forests must, therefore, be added.

The above table includes both capital and ordinary recurring expenditure. Details of capital expenditure are as follows :—

(*a*) *High Bunds of* 1915 (*including Acquisition of Land*)

Year.	Stream.				Total.
	Shwele.	Taungnyo.	Bawbin.	Minhla.	
	Rs.	Rs.	Rs.	Rs.	Rs.
1915	9,125	51,644	38,746	8,132	107,647
1916	—	1,425	—	509	1,934
1917	—	2,458	2,121	—	4,579
Total . Rs.	9,125	55,527	40,867	8,641	114,160
£	608	3,702	2,724	576	7,610

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(*b*) *Low Bunds of* 1916 *on the Taungnyo*

1916, Rs. 13,448; 1917, Rs. 8,286; 1918, Rs. 1,347; total, Rs. 23,081 (£1,539).

(*c*) *Laha Clearing and Leading Channels*

Year.		Stream.							Total.
		Shwele.	Taungnyo.	Bawbin.	Gamon.	Myole.	Minhla.	Myitmaka.	
		Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
1914		—	—	—	—	—	—	8,464	8,464
1915		833	5,613	1,509	1,555	—	—	6,768*	16,278
1916		—	500	—	1,891	—	79	—	2,470
1917		—	2,253	—	1,003	1,637	—	—	4,893
1918		—	3,363	—	371	2,281	—	—	6,015
Total .	Rs.	833	11,729	1,509	4,820	3,918	79	15,232	38,120
	£	56	782	101	321	261	5	1,016	2,542

* Digging in Mingyi Chaung at Kaingdawgyin 1,530
Short cut in Myitmaka below Bithalun . . . . 5,238 } 6,768

(*d*) *Purchase of Skidder No.* 2

For Taungnyo in 1915, Rs. 11,419 (£761).

Total capital expenditure, Rs. 186,780 (£12,452).

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CHAPTER X

EXTRACTS FROM OLD REPORTS

EXTRACT NO. 1

MR. GORDON'S REPORT ON THE IRRAWADDY, 1879

* * * * * *

PART III.—SECTION V

The Pegu Sub-Yoma Plain and Yoma Torrent Streams

104. The Pegu Sub-Yoma plain is bounded on the north by the Nawaing (Nawin) River, which enters the Irrawaddy at Prome; on the west in its northern part by the small meridional range of hills running south from Prome, and in its southern by the Hline (Hlaing) River. To the east it is fringed by the high land and spurs of the Pegu Yomas, containing the torrent streams running down from these hills to the Hline, and which give rise to the most difficult of the hydraulic problems affecting that plain. Streams south of the Thongzai (Thonze) Choung * occasion few difficulties of this kind. The hills from which they spring are generally low, the ridge averaging less than 600 feet in height, and their reception basins in the high ground are not large. As a rule these streams run with steep banks and clear, though tortuous, channels through the plains till they enter the Hline River, which carries without difficulty any silt they bring.

105. This plain to the north of Thongzai is about ninety miles long by fifteen broad, thus containing approximately 1,350 square miles. Its slope from north to south is about 1 foot per mile, while it varies much from east to west, being steep near the base of the hills and softening to an almost imperceptible fall near the Hline River. It is intersected by several watercourses.

* * * * * *

The principal torrent streams, taken in the order of their distance from Rangoon on the railway line, are given below with their reception basins in the hills, and their sectional area where crossed by that line.

106. The nature of the questions that have arisen regarding the condition of these streams cannot be better shown than by an extract from an official letter of Mr. Weidemann, Assistant Commissioner of Tharrawaddy, and now Deputy Commissioner, Henzada, to the Deputy Commissioner of the district, on the subject of which the writer was called to report.

* *Chaung* = stream.

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TABLES 19 AND 20

Miles of railway from Rangoon.	Name of torrent stream.	Approximate sectional areas of stream at railway line in square feet.	Approximate area of reception basins in square miles.	Ratio of square feet at railway to mileage in basin, 3 ÷ 4.
1	2	3	4	5
69	Thongzai (Thonze) . .	3,000	160	18·8
78	Letpadan (Bilin) . .	1,350	84	16·1
91	Sagaing (Mokka) . .	660	48	13·8
97	Minhla	585	36	16·3
103	Goy (Myaung) . . .	405	30	13·8
105	Gamoung (Gamon) . .	600	40	12·0
117	Bobin (Bawbin) . .	800	156	5·1
118	Minboo	660	40	16·5
128	Kantha (Taungnyo) . .	1,350	176	7·7
137	Shoaylay (Shwele) . .	1,350	230	5·9

Mr. Weidemann's Charges against the Forest Department

(Letter dated August 3rd, 1877)

"I have the honour to forward herewith an estimate for making a bund along Kantha (Taungnyo) Choung in order to check the overflows from that stream.

"The portion proposed to shut in extends roughly for two miles on each side of the road between Tahpoon (Tapun) and Poungday (Paungde).

"Owing to the destruction caused of late years by the floods from the Kantha, portions of the road to a considerable distance north and south of that stream have been rendered impassable, and so hopeless is the repair of the road apparently deemed under the present condition of the Kantha that the bridge over the stream itself has been this year dismantled. The effects of the floods are seen within a mile of Tahpoon, four miles from the *choung*, and equal disaster is, I believe, caused on the Poungday side.

"It must not be imagined that the stream was always subject to overflows. . . . Four or five years ago, I am assured, the depth of the stream in the Rains was the length of a bamboo.

"The channel is now reduced for some distance to a depth of 3 or 4 feet or even less, through which a man can easily wade, and in the middle of which buffaloes can wallow. Such a channel is obviously incapable of carrying off the same volume of water as heretofore, especially during the freshets which come down from the hills at intervals during the monsoon. The country on both sides is, therefore, subjected from time to time to a rush of water of considerable violence, which has not only partially destroyed the only road besides the Prome road which has hitherto existed in the Tharrawaddy, but has also laid waste a large tract of land formerly devoted to cultivation on both banks.

"The cause of all this is, I believe, not far to seek. It is the same which has operated so disastrously on most of the hill streams of the Tharrawaddy, but in no case, not even in that of the Beeling (Bilin), so disastrously as in the case of Kantha. It is simply, if unanimous testimony is to be trusted, the careless manner in which logs of timber are floated down these streams from the hills above The fact, indeed, is so notorious that the officers of the Forest Department do not attempt or care to deny it.

"It is true that in his letter No. 1,202—110—6C, dated 25th March, 1876,

For ease of reference the modern spelling or equivalent of Burmese names is given in brackets.—F. A. L.

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the Assistant Conservator, Myanoung, invoked the aid of my predecessor in preventing villagers from throwing refuse into the timber-conveying streams, which he said is one of the chief causes of the formation of the obstructions and the consequent inundation of the country. It is possible that this may be true, but the original sin lies at the door of the people who extract and float timber; mere refuse would be carried safely down any one of the hill streams were it not that here and there it meets a log jammed in its path. The two together then unite and arrest the silt which the stream carries down with it, and which, instead of being carried off, is thereby precipitated with great rapidity and in great quantities into the bed of the current. From this moment the closing of the channel is merely a matter of time, and the closing of the channel leads naturally to inundation.

"It is, however, not of much use to resort to recriminations. The mischief has been already done, at least in the case of the Kantha, and it remains to consider a remedy.

"The most obvious remedy is to dig out the bed of the stream. When this operation has to be carried out along a length of some three or four miles, the cost is so great that it is not likely to be undertaken except as a last resort.

"The plan now advocated is to run parallel with the stream a cheap and close fence, along the inner side of which during the overflows a natural embankment of silt will be formed by the operation of the current. That silt will thus form is shown by experience. During the inundations the stream has exerted greater violence in some parts than others, thereby wearing away the bank and forming ditches which run a long distance into the country, and help to spread the overflow. To close the entrance to these channels, the villagers have already erected wattled fences, which have served the purposes of arresting the silt and damming the channels. In erecting a similar fence for a length of four miles care will, of course, be required to make it strong enough to withstand the first rush of the shallow stream as it brims over. When silt has once formed in sufficient thickness the fence will have done its work.

"The effect of bunding one bank of the *choung* will, of course, be to leave the other (the Poungday) side more exposed than ever. This could be avoided by bunding both sides."

* * * * * *

107. This letter accosts a topic which has caused much bitter controversy for the last twenty-five years, or ever since the Forest Department commenced its operations, and in which the officers of that branch of the Government service have been accused of damaging nearly the whole of the upper part of the plain under consideration by the methods in which their operations have been conducted. Not only the civil officers, but the engineers of the railway and the roads in that quarter, have taken up the question from time to time, and, as the works under their charges have suffered, have assailed the Forest Department as the cause of the evil. The Forest officers have had not only to undergo loss of much valuable timber covered by the silt—and hundreds, if not thousands, of tons of the best teak have disappeared in swampy sediment—and to incur the expense of opening up fresh channels occasionally, but have had to defend themselves from the charge brought against them of being the sole cause of the evil. There has been a great expenditure of controversial power, but the condition of things has not improved. Indeed, as the late date of that letter and its contents show, things have gone worse, and are apparently intensifying to a climax.

108. The writer had charge of the roads from Prome to Thongzai (Thonze) from 1865 to 1868 and obtained an intimate personal knowledge of the whole

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of that plain country. He constructed the road referred to from Poungday (Paungde) to Tahpoon (Tapun), and laid out, and in part constructed, the embankment on which the present railway is carried from Thongzai to Poungday. He had not only to examine the question in connection with those works at that time, but was deputed to report on other injurious results of a similar nature principally in the lower part of the Shoaylay (Shwele) Choung, where a canal had to be excavated in 1867. He then took much the same view that is given in the letter quoted, that the Forest officers are primarily responsible for the damage done, but a further study of the question has brought some modification of his views, which at this interval of time tend to be more impartial.

109. The true cause of the unhappy state of the country is due to the soft nature of the strata in the reception basins of the torrent streams of this part of the Pegu Yoma.

* * * * * *

110. We have in this soft and easily decomposable condition of the rocks of the Pegu Yoma the primary cause of the evil, a cause which exists independently of all human agency. The extent to which its effects may reach can be inferred from the position of the Hline (Hlaing) River, the general drainage channel of the country, at such a distance from the hills. The distance clearly indicates that the process of excavation and redeposit to which the existence of the whole plain is primarily due must have always proceeded with great activity ever since the Yoma rose above the ocean level. Whether these effects have been intensified or can be moderated by the hand of man is an enquiry of the utmost importance, which becomes more pressing every year. A general statement of what has occurred within the last few years on the channels of the principal torrents will assist in elucidating or clearing the way for an answer.

111. The Hline River marks out the lowest part of the plain. Its most northern branch is called the Zay Choung, which has a torrential reception basin of some forty miles within the lower spurs of the Pegu Yoma. A further gathering ground of sixty square miles in high plain land brings it to the Mahathaman plain, east of Prome, where the bed of deposit of the silt is found.

* * * * * *

112. THE ENGMA LAKE.—From the Mahathaman plain southwards the Hline flows in a broad and shallow undefined channel through a series of lakes or swamps. The most southern of these is known as the Engma (Inma) some ten miles long by four wide after heavy and continuous rains. They shrink very much in the dry weather, but effectually prevent cultivation. They are caused by the cone of deposit of the Shoaylay (Shwele) or Wetpouk (Wetpok) Choung being thrown into the bed of the Hline where it joins it, some twenty-five miles south of Prome. The water after being reservoired in these lakes flows sluggishly through the southern outlet. Two or three miles above the Shoaylay junction the Prome and Poungday road crosses the Engma swamp. The writer in 1866 proposed a bridge with a single waterway of 40 feet across this, and the waterway was ordered to be reduced to 35 feet, which with a depth of 12 to 15 feet forms the sole exit to the drainage of over 300

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square miles of plain country. This exit would be too small if the drainage were put in proper order ; and if ever this is done a new bridge will have to be substituted with much larger waterway.

113. The high flood level of 1875 at Prome is about 93 feet above mean sea level (M.S.L.), and according to Colonel Stoddard's levels the bed of the Engma swamp under the bridge is 58·5 feet, and at the junction of the Shoaylay and the Hline it was in 1869 57·38 feet above the same datum level. In 1866 and 1867 it had been raised so much that the Engma lake expanded and swamped large tracts of cultivation on its borders ; and a channel was cut by the civil officers through the bed of deposit. It lowered the waters somewhat, but was of too small dimensions, being not over 6 feet deep and 8 or 10 wide, to effect much improvement. Large tracts of good ground were also submerged by the silt. The writer had on different occasions to examine these tracts. The Forest Department officers also cut channels to relieve the Shoaylay Choung, and to provide passage for their timber through it. Mr. Ring, Executive Engineer, has surveyed within the last few years the region damaged, and states that it has much extended.

114. The Kantha Torrent. Advance of its Bed of Deposit.—He also had to remove the bridge on the Poungday and Tahpoon road crossing the Kantha Choung and referred to by Mr. Weidemann. The writer has been able to consult both these officers lately and to learn some of the latest changes occurring in the beds of deposits and channels of the principal torrents since he personally examined them previous to 1868. An old Burman wooden bridge stood on the site of the newer one, which was put up after the construction of the road. The floor of the old bridge was some feet below the ground level. The channel and bed were clear, and the floods rarely, if ever, topped the banks. The new bridge was made higher. The neighbouring plains were almost never flooded near the stream previous to 1868. The new bridge was on wooden piles, and did not change the *régime* of the stream in any way. In ten years the whole lower course of the stream has deteriorated. The bed of deposit has advanced steadily upstream, filling the channel, and as the water overflowed the sediment has been deposited over all the cultivated ground. It is unfortunately mostly siliceous sand, and thus does not benefit the ground. It is not possible to state the exact area of ground injured, but in all it is some thousands of acres. The head of the bed of the deposit is now a mile or two above the bridge. The channel beneath this got filled, and the structure had to be removed. The road constructed in 1867 has been partially destroyed, and some Rs. 30,000 or 40,000 spent in its construction wasted. Mr. Weidemann states that the stream, having once shed its silt, resumes a single channel below its new bed of deposit, thus having cut itself a course through its former silt. There is every prospect of the cone of deposit going still further upstream to reach the railway line, when it will render the bridges there useless ; and new waterways must be cut. The necessity of effectual remedial measures with both the Shoaylay and Kantha torrents is thus of the utmost urgency.

115. The Bobin Torrent.—Both the Shoaylay and the Kantha have their reception basins in the higher parts of the Yoma, the area of the former being about 230, of the latter 176, square miles. The size of both in 1868, where crossed by the Prome and Poungday road and by the railway, was similar. The

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writer had to design iron bridges for these, the spans being in each case 96 feet, and the greatest depth of water about 20 feet, their cross sections being approximately 1,350 feet, thus giving a smaller ratio in proportion to drainage area for the former. The causes of this will be discussed presently, but they are now brought forward to contrast them with the cross section of the Bobin (Bawbin) Choung in 1868 where crossed by the railway line. This was then only 800 square feet, although the reception basin of the principal branch has an area of about 196 square miles, and is immediately contiguous to that of the Kantha in the Higher Yoma. This small channel was entirely due to the reception basin having advanced above the line of the railway. It had done so long before that line was laid out. The channel of the principal stream before it leaves the hills near Bobin is about 200 feet wide and 15 to 20 feet deep, but it was broken up into several small channels on the cone of deposit, and inundated the whole country. A large number of waterways had to be given where these crossed the embankment, which they mostly did in 1868, following the line of the Wet Choung ; but since 1868 the whole course of the stream had been changed from where it leaves the hills, and one of its channels runs due east to join the Choung-Souk or Minboo Choung near Zeegon (Zigon). Probably the bed of deposit had ascended as far as the exit gully from the hills. The water is still spread in several channels and inundates the country, but the one channel serves for timber-carrying purposes. No positive harm has been done to cultivation, for the simple reason that the stream has never permitted any to exist within the limits of its devastations ; but if it could be controlled a larger tract of good ground would be rendered available for cultivation close to the railway. The Minboo and other streams from the outer flanks of the Yoma in this part have a total basin area of about forty miles on the hills, and, beyond inundating the country in floods, do little harm.

116. It is difficult to say when or how the Bobin Choung commenced its divagations. It can hardly be due to the action of the Forest Department so far back as 1859–60, when the operations had only been a few years in progress.

* * * * * *

117. THE MINHLA TORRENT.—Dr. Brandis, Inspector-General of Forests, writing in 1856, mentions the Minhla Choung as an instance " where every log has for a long distance to be dragged overland by buffaloes before reaching the lower unobstructed part of the river." This stream at present receives four separate torrents from the higher parts of the Yoma : the Too, the Gamoung, the Goy and the Minhla. Formerly the first had a separate course to the Hline, but has now joined the Too and Gamoung above the railway line. The reception areas appear to be about thirty, forty, thirty and thirty-six square miles respectively. The Minhla, which formerly was troublesome, has now ceased to be so in the higher parts ; but the Goy Choung has formed a new bed of deposit just below the railway line, and is rapidly filling its channel there. A large tract of country in the vicinity is annually submerged, with much loss to cultivation, which is still attempted in a precarious manner. The sectional areas of these streams at the railway were about 600, 405 and 585 square feet in 1868.

118. The last of these torrents to be noticed is the Letpadan (Bilin) Choung, which debouches at Beeling (Bilin), on the Hline. The condition of this stream

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has deteriorated much within the last few years in the lower parts of its channel. Mr. Weidemann has had to report on its devastation. Its bed of deposit has steadily advanced up the channel to beyond the railway, where the large creek has been partially filled. This in 1868 had about 1,350 feet section and was a fine, clear stream. . Now several channels break through or over the alluvium above the railway, and have necessitated a rebuilding of several bridges with increased width of waterway. Damage has been done to a large extent of country, and probably 3,000 to 4,000 acres of cultivation in the immediate vicinity ruined. The reception basin of this stream is about eighty-four square miles.

119. General Deterioration of the Pegu Torrents.—There is thus clear evidence of several changes, and nearly all for the worse, in the condition of these torrents, and in the country contiguous to them. The beds of deposit have in many cases raised the channels of their own streams, and have advanced towards the hills. In other cases the beds of deposit may have remained near the Hline, but they have then either injured that river or lie wholly within the area submerged by the great annual inundation, where their vagaries are not noticed. It is likely that in almost every case the need of amelioration will become more pressing from year to year.

* * * * * *

120. The causes alleged for the progressive deterioration are three : (1) The floating down of logs of teak, etc., by the Forest Department, which, getting entangled in a channel of the stream in a falling freshet, as described by Dr. Brandis, get covered with silt and cannot rise with the next flood, which then tends to increase the obstacle. (2) The Forest officers allege that the cutting down of trees and jungle for *taungya* cultivation is the principal cause. (3) Some of the people allege that the embankment works on the western side of the Irrawaddy have increased the Hline floods, and by backing up the flow from the torrents streams have caused their beds of deposit to advance higher up. All of these causes, so far as they exist, are efficient and tend to produce the effects described there.

121. That the first cause does exist is undoubted, but it is far from being the sole one. Dr. Brandis admits and correctly describes the process. It has been the unremitting effort of the Forest officers to overcome the evil, both on their own account and that of the country affected. That they have not succeeded in their efforts is owing to other causes of more potency having been conjoined to produce the effects. This would soon be seen to be the case if all the timber floated by these streams were caught and taken out near the railway for conveyance by it instead of it being floated down to Rangoon through the Hline. The experiment might be tried on one of the smaller streams where the injuries to the country are grave ; and if found at all successful, and the cost of extraction and conveyance not too great, this operation could then be extended to all the other streams.

122. But, in the writer's opinion, the view advanced by the Forest officers gives a more correct indication of the immediately efficient cause of the evil. The soft nature of the rocks must always have been, and will always be, the primary difficulty to contend with ; but the progressive deterioration of the lower plains has advanced *pari passu* with the spread

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of the hill cultivation, which has increased with the general prosperity of the province.

123–124. * * * * *

125. Application of Protective Operations in Burma. Reforesting and Grassing.—The first step in the amelioration of the torrents of the Pegu Yoma has been taken by the Forest Department in the protection of its own interests. The whole of the districts in the reception basins not actually under fixed cultivation have been proclaimed, and the village lands demarcated. The *taungya* cultivation, formerly so destructive, is now generally prohibited in the forests. Possibly by natural agencies the grassing and rewooding of the slopes and torrent beds may take place; but if not, the agency of that department might intervene with advantage, and by a careful selection of those portions of the basins of reception where the ravining is at present most destructive for operations of direct culture of the most suitable grass and shrubs attain as satisfactory results as those obtained in France.

126. Other Operations in Extreme Cases: Barrages; Storage Dams.—In the worst cases of ravining, which are generally of very restricted area and which often are the sole causes of the worst features of the destruction in the plains below by the amount of silt they yield, stronger measures are necessary. Barrages are the most useful of these works. They consist of various kinds of dams thrown across a ravining channel, and vary from simple fascines of grass or reeds pinned down to elaborate works of wood piling and stone. In the torrent of St. Martha, whose perimeter embraced 530 hectares (1,130 acres), no less than 800 barrages were constructed, differing considerably in dimensions and in the mode of construction. In the present condition of this country it would perhaps be unadvisable and unnecessary to carry out such a system as this, but some measures of the kind are undoubtedly necessary. The able officers of the Forest Department would doubtless be able to point out and suggest the most economic and efficacious remedies of this kind which could now be advantageously employed in the Pegu Yoma. If, as is not improbable, it may eventually become expedient to employ irrigation over the Pegu Sub-Yoma plains, the engineers who carry out the works can readily devise means of combining extensive barrages with dams to store up the water requisite.

127–128. * * * * *

129. Other Improvements required.—The protective works of grass culture, barrages and irrigation dams in the reception basins of the torrent streams of the Pegu Yoma will not of themselves be sufficient for the amelioration of the Sub-Yoma plain. Without them nothing can be done in the plain itself. No embankments for streams, or canal cutting, or diversions of channels will be of the least avail in the lower plains, if the ravining and excessive excavation of earth is not stopped in the reception basins, but this once achieved or in fair progress, other improvements become possible, and are required. The creeks, when they once enter the plains, commence overflowing and spread their water and silt over the whole country in the neighbourhood. This gradually diminishes the amount of water passed on through the channel in successive lengths of its course. The sectional area of the channel also diminishes, so that if cross sections were taken at every half-mile of any of these creeks from its exit from the hills to its entry into the Hline it would be seen

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that the capacity and contents of the creek in floods lessen continually towards its mouth. Practically the bed of deposit commences at present at the exit gully, though on a small scale. A comparison of the basin areas and the capacities of the various streams where crossed by the Prome road and railway, as taken by the writer in 1868, makes the discrepancies of the carrying powers of the channels manifest. These are given in column 5 of the tables in para. 105.

130. The stream with the largest capacity at the railway line is the Thongzai (Thonze), which has 188 square feet of section naturally for every square mile of country drained. This stream is in fair condition, though in certain parts it spills over its banks, and diminishes in size as it reaches the Hline. It continually excavates and readjusts its channel throughout the length of its course in the plains. It has, notwithstanding a very tortuous channel, a comparatively short length to run after leaving the hills, not more than ten or twelve miles in the plain. Possibly its immunity hitherto has depended on this shortness of course. The streams with the least waterways at the railway line are the Bobin (Bawbin) and the Shoaylay (Shwele), both of which were in 1868 in the worst condition of all the torrents. The Kantha (Taungnyo) must then have been deteriorating in the lower inundated country, where it escaped notice, since it had only 77 square feet for each mile of reception basin. A study of these basins on the map shows that they are in the same condition with each other so far as the facility for gathering and distributing the rainfall is concerned. We know that geologically the strata are the same throughout ; and though the rainfall progressively diminishes from south northwards, it does so gradually and slightly. If this were the same in all, the ratio of the channels when they leave the reception basins must be nearly the same. No accurate measurements are available, but it is known that all the above streams, including the Thongzai one, are larger at the exit gully than in the plains below. And it is an indispensable condition to the reclamation of the plains from inundation from these streams that the capacities of their channels should be enlarged throughout their courses in the plains to that which they have at the exit gully. Otherwise they will continue to spill over their banks and lose both water and the excavating power over their channels. When once the water issuing from the hills is freed from its excess of silt by the measures indicated, it will be necessary to guide by light embankments the waters in the channel through the plain. The fall from the hills is great enough to give a dynamic head to the stream in every part of the plain sufficient to allow for carrying the water and at the same time excavating the channel to a proper size. Possibly groins and guiding piers of a light kind may be necessary at first to keep the action more on the bed than on the banks ; and each stream will require regulating. But if this is done all these torrents will eventually excavate for themselves channels large enough to pass all the hill drainage they are called upon to carry without damage to the intervening plain. The experience gathered on the torrents of the Alps and other countries justifies these expectations.

131. That the slope will be sufficient for the streams may be gathered from the levels given in Plate 7, Figs. 5, 6, 7, and 8. Fig. 8 shows a section across the delta below Henzada. The last part of it gives the fall from the base of the hills near Letpadan to the Hline. The fall in the first three and a half miles is

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9 feet per mile. In the next four it is about 4½ feet; and in the last four it is only 1¼ feet. The last has been proved sufficient for excavating a channel, as the ordinary drainage streams flow in clear, well-defined channels. They have little silt to convey, and vary but slightly in their courses. The excess slope in the higher land is used by the stream in working out sinuosities in its course, as evidenced by the Letpadan Choung. If this is moderated by regulating works the excavation will be utilised in enlarging the channel. Further north the slope across country is smaller, as the plain is broader. The levels taken from Poungday to Tahpoon show an average fall of over 3 feet per mile in ten miles. For the last four miles from Tahpoon to the Hline it is about 1¼ feet per mile; but the banks of the stream are here higher than the plains. The slope given is what is available for both the Kantha and Shoaylay Choungs, and is ample to enable them to clear out their channels, provided the water can be delivered to them in the plains not overcharged with silt, and regulating operations are put in hand to control them.

132. Extent of Plain to be Ameliorated by these Operations.—The portion of the plain which will be ameliorated by these operations conducted to a successful issue lies between the limits of the ordinary inundation of the Hline and the base of the hills. Deducting 500 square miles from the whole extent of the Sub-Yoma plain for this inundation, we would have over 800 square miles of plain land placed in security from the torrents. At present from one-half to two-thirds of this is either entirely uncultivable or in a precarious condition from these sources. When the roads were made in 1866–68 cultivated land could be obtained, and was taken up for the roads at from 12 to 25 rupees per acre. The carrying the railway line through it has immensely increased its value, and now near towns and large villages it occasionally brings from ten to twenty times those amounts.

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133. The Cause of Deterioration.—The annual inundation of the Hline valley from the Irrawaddy no doubt has considerable effect in retarding the flow of the torrent streams and thus causing them to deposit their silt in so many deltas on the river banks. And it is undoubted that this inundation has increased of late years, the increase being more marked through the effects of the great flood years 1871, 1875, and 1877. It has been fully demonstrated that these floods, although they have occurred since the embankments were constructed on the western side of the Irrawaddy, did not arise from that cause. The dwellers in the neighbourhood of the Hline, however, may not know that at Mandalay, at Thayetmyo and at Prome, far above the reach of the embankment works, the floods of the years mentioned were as abnormally high as in the delta, and therefore must have had origins independent of any delta works.

The Thambyading Bend.—But in the upper part of the Hline valley, and particularly in the region where the torrents we have been considering enter, there has been a gradual and persistent elevation of the flood level for a considerable period of time. It has affected the Irrawaddy equally with the Hline. It has increased since the embankment works have been developed, but was in progress before they began. It is due to the formation of a great bend in the Irrawaddy, a few miles above Henzada, which has been taking place for the last fifty or sixty years, and which is now working towards a crisis. As is

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well known, such bends cause an elevation of the river surface above them, and a lowering below them, so that a double effect has been produced. The extent of this will presently be considered. It suffices now to note that the complaints of the people that the Hline surface has been raised are well founded, though they are wrong in ascribing the Irrawaddy embankment as the cause of it.

134. Some projects for communication and navigation affecting the plains on both sides of the Hline have been from time to time brought forward.

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It was proposed to run a road from Tahpoon to Talokmoh (Talokhmaw), and one survey was made ; another surveyed and levelled by the writer was proposed from Tahpoon to opposite Myanoung. Both were found impracticable, as embankments would be required from 12 to 20 feet high to rise above the flood level and would interfere with the flow of the inundation water which moves slowly southward. Levels have also been taken at other parts of this inundated land. There is a great fall from the Irrawaddy bank to the Hline banks, amounting to nearly 10 feet on the Tahpoon-Myanoung road, while at Sanyuay (Sanywe) the fall is nearly 22 feet (Fig. 8, Plate 7). This last shows the preliminary levels of a cart-track near which it is contemplated to carry a branch line of railway from the Prome and Rangoon railway at Thongzai to Henzada. The project is now under consideration, and the writer has received orders to carry out the necessary surveys and designs. **It is proposed to carry the line on an elevated trestle work,** a few feet above the highest flood levels. The flood line is irregular, sloping from the Irrawaddy towards the Hline, where some 14 feet of water were found on the banks in 1875 and 1877, and again sloping upwards from there towards Thongzai. The Thongzai (Thonze) portion would be embanked, the height of the work being nearly 20 feet for two miles, and from 12 to 15 for another three. By carrying a straight line from Sanyuay to the nearest point on the Irrawaddy the distance can be reduced to eight miles through the inundated land. **The trestles** are intended to be of ironwood posts resting in cast-iron shoes tied together by iron rods and buried beneath the surface, and carrying a rigid superstructure of teak and iron, where the rails would be laid on longitudinal girders. The railway is of metre gauge ; and as there is no probability of heavy goods traffic, both lighter permanent way and lighter rolling stock than are used on the main line can be employed. The want of rapid communication with Rangoon is much felt ; and unless it is decided to proceed with the reclamation of the entire Hline valley some such project must be seriously entertained.

135. Proposals have been made for improving the navigation of the Hline. Cross sections are given in Plate 5, para. 63, for this river in different parts of its course. These were taken in 1868, and little variation has taken place in the capacity of the stream since, though considerable changes have occurred on individual sections through excavation of the banks. From these sections it is seen that the river increases considerably in capacity in its downward course, even when measured within the banks. At Mindu, on the Tahpoon road, when it has received the Shoaylay and Kantha streams, it is 180 feet wide, and in one part about 20 feet deep. There is a decided tendency to silt up here at present, which has been encouraged by fishermen's dams thrown across the channel as the river falls. At Shwayloung the river has received the drainage

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of a large portion of the plain land as well as the water from the several torrents flowing down by Mindu. It has also received the first large branch from the Irrawaddy, the Teindau (Teindaw). This branch when measured in 1874 was 240 feet wide and 20 feet deep at its mouth. For the past fifteen years the Irrawaddy entrance to this has been in course of silting up, and a long tongue of land has formed in front of it. It commences to flow when the river is at half flood. The Hline after receiving it is 338 feet wide. The depth of water in March, 1868, was 7¼ feet, and depth from edge of bank to bed 26½ feet. Its sectional area was approximately 5,400 square feet. From this part southwards it excavates its channel. At Sanyuay (Sanywe), just above the mouth of the Thongzai Choung, the Hline is 680 feet wide, with a depth from bank to bed of 44 feet and dry weather depth of 12 feet. The rise and fall of the tide are here about 3 feet. Its approximate area within its banks was then about 19,000 square feet. At Emg-ka-bore (Inkabaw), above the town of Hline, its width was 523 feet, cross section about 22,000 square feet, and depth of water over 20 feet in the dry weather. The river, though sinuous, is navigable for large boats and steamers to the north of Sanyuay all the year round, but the immense spread of the inundation and the absence of cultivation cause it to be little required for navigation. The railway parallel to it now takes away most of the traffic which formerly sought it, and unless the plains on both sides are reclaimed and cultivated there can be no object in attempting to improve its channel. Precautions will, however, have to be taken when the regulation of the torrent streams is put in hand, as this will have the tendency to bring down the whole of the silt they carry into the Hline, where, if allowed to deposit immediately, it will cause serious obstruction to the channel. When once the protection is afforded from the Irrawaddy floods, and the Pegu Yoma torrents are dealt with, the problem will assume a new form and importance. It will also best be dealt with then, as the various changes carried out will suggest new methods of dealing and new requirements. In the meantime the writer would place upon record a protest against such a scheme as Colonel Stoddard proposes, which is to cause " the waters of the Irrawaddy, supplemented by the discharges of the Nawing and Loothat Choungs," to " be permanently diverted into the Hline." The object of this proposal was " to make a navigable canal, which can be used throughout the dry season, of about 6 feet deep, a portion of the cutting in the distance between the mouth of the Nawing and the fifth mile " being " very heavy, not less than 43 feet." This canal would require locks and head sluices to regulate the flow. As the whole of the district of the Hline valley where this river is not navigable in the dry season is within a few miles of the railway or of the Irrawaddy, it would be inexpedient to carry out works of such a grand and expensive character, even if success could be ensured. The Nawing itself is a large torrent stream, with a greater reception basin than any of those of the Pegu Yoma yet considered. Its width near its mouth is over 200 feet and depth over 20 feet, and large bodies of water rush down with extreme velocity and violence. One of the first projects for the redemption of the plain should be to embank the Nawing and keep it altogether excluded. Navigation is here altogether of secondary importance to protection and irrigation.

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EXTRACT NO. 2

NOTE BY LIEUT.-COLONEL SCOTT-MONCRIEFF, R.E., C.S.I., IN MAY, 1882.

Having just returned from a rapid inspection of some of the Tharrawaddy hill streams, I proceed, while it is fresh in my memory, to record what I have observed and to make some suggestions, premising that the treatment of such rivers is everywhere recognised as a most difficult engineering problem, and one on which much cost and talent has been bestowed in America and several countries of Europe as well as in India. It is a problem that must be faced, however, if we are to insure the railway and our new system of roads from danger, as well as the rapidly extending cultivation of a large tract.

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2. On the morning of the 3rd instant we visited the railway bridge over the Bilin River about two miles south of Letpadan. Downstream of the railway a long straight cut was made some years ago. This appears to have become considerably silted up, and during last monsoon the river breached its right bank just below the railway and spread over the rice cultivation, burying it in sand. This breach is now being closed by the Executive Engineer, Mr. Collings, a step quite necessary to be taken.

3. Mr. Collings has written a very good report on the course of the Bilin between the railway bridge and that proposed for the Rangoon-Prome road about two miles upstream. He recognises the deltaic character of the river, that its bed and banks are higher than the adjacent country. He points out that the bed is silting up, its section at the railway being 100 by 8 feet, while at the Prome road it is 140 by 15 feet, and he says this is partly occasioned by two outlets from the river, one right and the other left. These convey what is really Bilin water to two bridges some distance apart under the railway. He very properly recognises that these outlets should be closed and the river confined to one channel, and to effect this he recommends that the channel should be embanked on both sides for the whole distance between the road and the railway.

I think ere long it may be necessary to take this step, but for the present simpler measures may be tried. At one place opposite Kidu village the right bank should certainly be raised and a groin put in to deflect the current here, which if not attended to will cut through the bank altogether. The outlets should be closed and watched, and the course of any flood water should be observed that does spill over the banks.

4. One difficulty is that the cultivators themselves make cuts in the banks to irrigate their fields, and, insignificant as these appear, they are quite capable of becoming the beginning of large outlets. I do not see how we can well stop these little irrigation cuts without embanking the river all along.

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7. On the afternoon of the 4th we went by train to Okpo and thence rode by Telagon and Thinzeik north-east to Shwepandaw, a distance said to be sixteen miles, in order to look at the hill streams of this tract.

There were three streams in question here, which to all appearances once crossed the line of the railway between Okpo and Gyobingauk by three distinct

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channels: the Gamaung (Gamon), the Taung, and the Myole. Of these the Gamaung is much the largest and the Myole the smallest. Some twenty years ago the Taung burst into the Gamaung, leaving its own channel at the village of Theinzeik. The abandoned part of its channel, now called the Kadot stream, has become very much silted up and obstructed. A 30-feet bridge is provided under the railway for this stream. Some ten miles above Theinzeik the Taung is joined by a small hill torrent on the right side of the Htu, and above this point the Taung, the Htu, and Myole all flow within about a mile of each other. Two years ago the Htu changed its course from the Taung and turned westward into the Myole, creating apparently such a draw in that direction that the Taung followed it, throwing up a sandbank some 6 or 8 feet high across its former bed. Since then the bulk of the water of the Taung and the whole of the Htu have flowed down the Myole, a small channel for which the railway bridge has only a 20-feet span. It was this circumstance that Mr. Ribbentrop was kind enough to bring to my notice last February. Either the Taung must be forced back into its former course, or the Myole railway bridge must be enlarged.

8. The interests of the Forest Department would best be served by turning the Taung back into its old course as far as Theinzeik and thence into the Gamaung, this being an important thoroughfare for the extraction of timber. In the interests of the railway also, the breach into the Myole must be closed. But Mr. Smith, Assistant Engineer on the line, has pointed out that within the last two years the railway village of Okpo has sprung up. It was badly flooded by the Gamaung last year, and he fears that if the Taung water is added this year, the damage may be still more serious. He would, therefore, like to see the old Taung channel (now called the Kadot) cleared out.

9. There is no sign of deltaic action in the Taung above the railway. The bed is deep and well defined. I doubt if the floods almost ever spill over the banks. But as one ascends the stream becomes more and more tortuous, and its channel (which is about 40 to 50 feet wide and perhaps 15 feet deep, with nearly vertical sides) is much obstructed by trees and logs. These obstructions occur every few yards, and twice we found dams built deliberately across the bed to pond up water.

It was at once evident that the Htu and the Taung must be forced back into their old course. Indeed, before our arrival Mr. Collings had commenced to close the breach connecting them with the Myole.

For the present year at least it will be impossible to clear out the Kadot. But the Executive Engineer should take an early opportunity of inspecting it, and report whether it is practicable or desirable to clear it. It would be difficult, even if desirable, to close the connection between the Taung and the Gamaung. The channel is a large and a deep one. Mr. Collings must also before the monsoon inspect the neighbourhood of Okpo and see whether it and the adjoining rice fields can anyhow be protected from flooding. I am not anxious about any injury happening to the railway here, for turning the Taung back into its former channel will only restore the state of things of three years ago. I was told that below the railway bridge the Gamaung is spreading over the country and doing damage, but we had not time to visit it.

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11. The 5th and 6th instants were devoted to inspecting the Taungnyo or Kantha River from the railway crossing north of Nattalin downwards and the road from Paungde to Tapun, which crosses its basin. This river has long been a source of anxiety and trouble. It is specially mentioned in Mr. Gordon's able chapter on the Pegu Sub-Yoma plain and Yoma torrent streams, in which a letter is quoted from Mr. Weidemann, C.S., dated the 3rd August, 1877, describing the mischief it was creating.

12. From the morning's inspection I cannot pronounce on the point now reached by the "cone of deposit," that is, the point where the stream begins to part with the sediment brought down from the hills. But it evidently has already passed above the railway bridge. At least, the river commences to spill its waters right and left above this point. Mr. O. Smart, Assistant Engineer, in an interesting report of March, 1881, states that five miles above the railway the river's channel is 80 to 100 feet wide, and from 15 to 18 feet deep, giving an area of about 1,500 square feet. At the railway the section is 1,459 square feet. At Tantabin, less than two miles below the crossing of the Paungde road, it is only 260 square feet, and the average section from the railway to Tantabin is not above 350 square feet.

13. The spill at the railway has been checked on the right by a low embankment running for 1,000 feet above the bridge, and Mr. Smith, the Assistant Engineer, pointed out to me how important it was that this embankment should be prolonged 500 feet, and that a similar, though shorter, embankment should be made on the left bank. Two groins are also required on the left bank. These works seem to me so desirable that, as there is little enough time before the monsoon, I sanctioned Mr. Smith's putting them in hand at once.

The present railway bridge is badly placed at a bend, and has its piers at right angles to the rails and at a very considerable obliquity to the stream. It is a timber bridge. I understand it is intended to replace it with an iron one. Its waterway of 160 feet (one span of 60 feet, two of 30 feet, and two of 20 feet) is probably enough, but the direction of the piers should be altered.

14. About 1,000 feet below the railway on the right bank I noticed the first spill of the stream. A quarter of a mile further on the left teak logs were lying stranded far out in the plain, and the contractor was closing the outlet through which they had been borne. Again, a little further down, above the village of Kantha, the bulk of the river seems to have escaped to the left, so contracted was its true channel, passing round north of the village, and here the contractor was making a long embankment. The bed here is not 4 feet below the banks. Beyond Kantha for the whole distance to Thapangon, where the Paungde road crosses, the river spills now to the right, now to the left, its own tortuous channel being unable to contain even an ordinary flood.

15. At the beginning of last year Mr. Propert, Deputy Conservator of Forests, proposed to improve the Taungnyo by turning it bodily three miles below the railway into the Tapun River, which runs roughly parallel to it on the south, passing through Tapun village. Mr. Johnstone, the Superintending Engineer, reported adversely to this project, and although I do not agree with all his reasons, or think he quite understood Mr. Propert's proposals, still I agree in thinking it would not be an advisable step. Where it is possible it is best to keep these hill streams each in its own basin and to regulate them separately.

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16. In the present instance I think it clear we must pass the river on within artificial banks from the railway bridge at least to below the Paungde road.

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Two lines of bunds generally, but not always, should follow the course of the river at a distance apart of from 500 to 1,000 feet, and within these banks the river should be further controlled by a system of spurs or groins to prevent its scouring along the face of either of the longitudinal bunds. I do not anticipate, except in a few places, that it will be necessary to cut a channel for the river. Possibly, when it has been levelled, it will be found that the natural features of the basin may assist this work by higher pieces of land here and there against which the banks may abut, and this may do away with the necessity of constructing them right through from bridge to bridge. But I am not sanguine of this. The banks need not probably be more than 5 feet high. What they are likely to cost I cannot say until the tract has been surveyed.

17. The object which I hope thus to attain is—

(1) To secure the cultivation on either side from ruin by silt deposit ;

(2) To secure the Tapun-Paungde road from risk of disaster.

This road has been repaired from the Taungnyo crossing on to Tapun and is carried in immense embankment. Had the river been curbed first, the embanked road might probably have been 2 or 3 feet lower, and it would not have required the 178 running feet of bridge opening that is being provided. The Commissioner of Pegu has lately reported that the people of the neighbourhood are alarmed at this great embanked road and fear that it will prevent the floods of the Taungnyo from running off, and they have begged that the river should be embanked. I think the length of bridging is sufficient to carry off any floods likely to come down ; but the cultivators may well look with dismay on this uncontrolled stream, which buries their fields in sand, and they are quite right in begging that it should be hemmed in. From the river to Paungde the road has not yet been renewed, and it will be done at a much smaller cost if these embankments are made first.

(3) I hope that the river thus confined will begin again to scour out its bed, and that the " cone of deposit " will recede to below Thapangon.

18. It will be asked, But what is to happen there ? Is the evil destroyed or merely transferred to another place ? Already the channel below Thapangon is not one-sixth large enough for the floods that pass the railway ; what will happen if these floods are passed on undiminished to Thapangon ?

As I have mentioned in para. 12, the area of the bed at Tantabin is only 260 square feet. From this point starts a cut made by the Forest Department about 8,000 feet long past Theikbeik to the village of Kebindaing. This cut so far seems to work well, but it evidently carries off only a small fraction of the floods, for at Kebindaing the area of the cut is only 133 square feet. The whole of this tract is some inches under water during the monsoon, and the floods pass through these villages 2 feet deep.

19. Mr. Smart in his report ascribes much of the flooding here to the Shwele River, which runs parallel to the Taungnyo on the north, and which formerly used to discharge into the great catch-water drain of all these torrents, the

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Myitmaka (or Hlaing) River, about five miles above the confluence of the Taungnyo with that river. Now the Shwele loses itself in a large swamp and fishery known as the Kya-Eng (Kya-In), and its waters and those of the Taungnyo flow on together to the Myitmaka. The swamp is probably only the outcome of the irregular deposits of sand brought down by the two rivers, deposits formed all the quicker owing to the reckless construction of fishery weirs. Mr. Smart rightly discerned that the Shwele and the Taungnyo should be treated separately and each confined to its proper area, and this he proposed to do by clearing out to a larger section and prolonging the cut made by the Forest Department below Tantabin and confining it between two powerful embankments for a distance of about three miles, thus excluding the Shwele waters altogether for that distance. The cost of this would have been Rs. 46,000. The Superintending Engineer, Mr. Johnstone, recommended the project for sanction, but I did not feel a year ago that I knew enough about it to enable me to do so, and the work was not carried out. Only one small 10-feet cut was made for a length of 4,400 feet, at a cost of Rs. 2,360, to float out logs. The upper part of this cut is now working well; the lower part is nearly obliterated by sand, but it might be well for the Forest Department to have it dug out again.

20. Generally, I think Mr. Smart's proposals were good; indeed, they were much the same as what I have been advocating for the improvement of the Taungnyo above the Paungde and Tapun road; but he was wrong in beginning where he did and not above that road. It is of much greater consequence that the river should be regulated there than lower down. If embankments are carried down to Thapangon, and no further, there will certainly be a great rush of silt-bearing water on to the plain below, and unless this water is regulated a swamp may result larger and more destructive than what now exists in the monsoon. I did not notice much cultivation west of the Paungde road nor know whether there are interests at stake there to render it worth while to lay out large sums.

21. The lower course of the Taungnyo, as of all the similar rivers, must be greatly affected by the floods of the Myitmaka (or Hlaing), and these again are influenced by the floods of the Irrawaddy itself; so here we get into a very wide field, and many considerations have to be taken into account. The first question is, What has caused the undeniable deterioration of all these torrents? Mr. Smart, and Mr. Johnstone with him, ascribe it—

(i.) To the deforestation and *taungya* cultivation in the hills;

(ii.) To the obstructions caused by the floating operations of the Forest Department;

(iii.) To the fishery weirs.

Mr. R. Gordon, who probably knows more about this subject than any one in Burma, says in his report already quoted: "The true cause of the unhappy state of the country is due to the soft nature of the strata in the reception basins of the torrent streams in this part of the Pegu Yoma." And this mischief has been intensified by the *taungya* cultivation.

22. The *taungya* cultivation has now, I understand, been brought under control. Mr. Gordon advocates the checking of the erosive currents of the torrents within the hill valleys by dams, such as have been used in similar cases

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in France, and the regulating of the streams after they debouch into the plains by excavating for them larger channels and guiding them by groins and embankments. · I have described in this note how I should deal with the Bilin and the Taungnyo. Evidence shows that these rivers are precisely similar to many others that traverse this district. Mr. Gordon says the area within their influence below the foot of the hills and above the annual inundations of the Hlaing valley is 800 square miles, in which fresh land is constantly being taken up, and which is crossed by a railroad and an increasing network of feeder roads.

23. The torrents come silt-laden from the hills ; any measures for reforesting and grassing the slopes, or any system of dams, must take years to complete, and we must be prepared for silt-laden floods for many years to come. My knowledge of the district does not enable me to say whether the deterioration of land is going on quickly. Perhaps the Revenue Survey officers could best tell us that. But I believe it must go on, and this is one of those cases in which the "stitch in time" may be invaluable. Unless we resolve to do nothing, and leave this district at the mercy of the floods, we must take some steps of the kind I have indicated; that is, we must convey the flood water, and the silt with it, to the edge of the Hlaing inundations.

24. The silt then will be deposited in the Hlaing. I do not know whether the land within these inundations is already so ruined by sand deposits as to be past recovery. It may be so ; and if we could maintain it just as it is, perhaps we need ask no more ; but this we cannot do. As we keep passing on fresh masses of sand from one torrent after another, we must raise the bed of the Hlaing, and we must raise the level of its annual inundations. It follows, then, that the Myitmaka or Hlaing itself must be regulated and improved ; and I believe every hydraulic engineer would pronounce that the first step in its improvement would be absolute separation of its waters from the floods of the Irrawaddy, that is, that the splendid system of embankments we already have on the right bank should be constructed on the left bank of that river.

25. To this conclusion I have been irresistibly driven, although I did not anticipate it when I first entered on the subject. I know it will meet with keen opposition. I daresay very weighty reasons may be given against it. As an engineer I know of none save the cost. That will be very large, and I would not advocate embarking on this great project without a much closer investigation than I have been able to bestow on it. But I think that investigation should now be made. . . . One thing certain is that keeping out the floods of the Irrawaddy will enable the country to be opened up freely by roads between the railway and the Irrawaddy bank, and it will render a branch line of railway not difficult from Thonze to the bank opposite Henzada.

From my knowledge of the subject, I believe that embankments on the left of the Irrawaddy, if accompanied by the regulation of the Hlaing River and Tharrawaddy torrents, will be a vastly more productive work than the Myanaung embankments on the right, which, fine as they are, have hitherto been of comparatively little service, since they have not been followed up by the improvement of the land in their rear. In the future interest of Burma I submit this subject for earnest consideration.

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NOTE BY MR. C. BERNARD, C.S.I., CHIEF COMMISSIONER, BRITISH BURMA, DATED RANGOON, THE 18TH MAY, 1882

Colonel Moncrieff's note respecting the streams of the Tharrawaddy plain will be of great use in guiding our operations in future years. It is rather late in the season to attempt much this year. But I am glad to see that he has ordered (para. 13) certain works to be undertaken by the railway engineer above the railway bridge on the Kantha stream.

2–3. * * * * *

4. The regulation of the Kantha stream is a very serious business, and has puzzled many people for some time back. Last year, when schemes were prepared, it seemed to me that Mr. Propert's plan, though not worked out in detail, was more reasonable than Mr. Johnstone's, which proposed a series of cuts-off and embankments to straighten and control the deltaic portion of the stream. One risk in making such cuts-off is that the stream will probably compensate itself for its loss of length by breaking out into new bends elsewhere. I think a plan for making retired artificial banks, as indicated in the Chief Engineer's sixteenth paragraph, is hardly open to the same risk, for space is left for the play of the stream. A scheme for doing this should be made as early as possible next season ; but for the present we must be content to deal with the lengths between the road and the railway and above the railway only. If a workable scheme can be made, then money will be available for beginning the work in February next.

* * * * * *

5. There must be great difficulty and many doubts about the best way of treating the Kantha and the other Yoma streams towards their mouths where they flow into the Myitmaka. No doubt they spill about and spoil the country. After we have dealt with these streams down to and perhaps somewhat beyond the railway and the feeder roads I think the Executive Engineer should consider their lower reaches and see what can be done. When the present system of Tharrawaddy feeder roads is finished, metalled and bridged, there will be engineering power and there will be money available for treating these streams as the chief work of the Tharrawaddy Division. The district might be attached to Mr. Gordon's circle of superintendence, for he admittedly knows more about the action and effect of the Burma flood waters than anybody else.

6. Perhaps in time to come the embankment of the left bank of the Irrawaddy may be undertaken in the interests of the Tharrawaddy District. Such a bank would stretch from a point opposite Kyangin down to Yandoon ; it would be about 120 miles long ; and it could not cost less than 12 lakhs of rupees. The maintenance of necessary drainage, navigation and irrigation channels, passing through the embankment, would cost several lakhs more. If the embankments on both sides stood, and if the great river at flood were to be really retained within these embankments as far as Yandoon, the effect of such retention on the lands of the delta proper might be prodigious ; I believe that nobody can possibly say what such effects might be. At any rate, this much is certain : the flood waters of the Irrawaddy River would no longer have access to the great basin of the Myitmaka (or Hlaing) River, into which those waters spill every year, and over which they stand for months to a depth

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of from 4 to 14 feet. The extent of this basin is about 120 miles long by an average of perhaps 12 miles broad, and may be about 1,500 square miles in all. When a heavy flood comes down the Irrawaddy it spills into the basin, which empties itself from time to time as the Irrawaddy level falls. The great river usually reaches a height at which its floods cause devastation only once or twice a year, and remains at the devastating level for a very few days only. The service done by this great basin of the Myitmaka in receiving the spill of the highest floods must surely be considerable. If all this water were retained within comparatively narrow banks, there must be great danger that it would rush down and devastate the rich lands of the delta. These lands are the richest, most productive and most populous in Burma. It is hardly too much to say that every square mile of cultivable land in the Twante, Syriam, or Pyapon deltas is worth to the country and to the people two square miles of cultivable land in the Myitmaka basin.

7. It may be that much of the water which lies over the Myitmaka during the months June to October comes from the streams which drain the western slopes of the Pegu Yoma. But even so all this water must get away to the sea somehow. If all these streams are trained as far as the Irrawaddy or Myitmaka and conducted through an embankment to swell the great river, their flood waters would only increase the volume of waters to be flung upon the rice lands of the lower delta. The theory that a river flowing in a restricted channel must hollow out for itself a deeper bed is very interesting. But can this operation go on after the stream meets the ocean tides ? Major Baird's observations have shown that the tide at Rangoon has an extreme rise and fall of nearly 20 feet, and this tide reaches up the several arms of the Irrawaddy far above Rangoon. Can we expect that any general erosion and hollowing out of the river channel will take place within tidal limits ?

8. It is perhaps needless to say that it would be almost impossible to protect all the delta by a great series of embankments. The whole deltaic area is intersected by streams ; it would require many hundreds of miles of embankment to protect all sections of the delta. With such protective embankments would have to be combined a great series of inundation and navigation canals if the country is to keep its present prosperity. We are now trying to embank a single little bit of the delta, the Ma-ubin island. It is as yet doubtful whether we can do this effectually within reasonable limits of cost, and it is still more doubtful what will be the effect of the embankment when done. If the bank is completed all round the island, one result must be that the formation of fresh land by Irrawaddy deposit round the trough in the centre of the island must cease, and the great self-acting reclamation, which Nature has been making for centuries, will be checked.

9. In the present state of Burma, and in the present state of our knowledge, I certainly could not advocate the erection of a second series of embankments on the left bank of the Irrawaddy from the toe of the Shwedaung hills opposite Kyangin down to Yandoon. According to our present lights, I would oppose proposals for any such gigantic interference with the operations of Nature. I would oppose them—

(i.) In the interest of the rich littoral, the prosperity of which would be jeopardised ;

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(ii.) On the ground that the public funds available for improving the country can be more usefully spent than in an attempt which may utterly fail to confine the Irrawaddy within artificial embankments.

10. If when we come to train the Western Yoma streams towards the Myitmaka we find that the land on the left bank of the Myitmaka (or Hlaing) is wanted, then perhaps a case might be made for a (comparatively light) embankment on the left bank of the Myitmaka through which the Yoma streams might be passed into the Myitmaka. Such an embankment might hereafter become feasible, and I do not think it would seriously affect the level of the Irrawaddy at flood. If any such bank were attempted, it should be begun far up the Myitmaka above Tapun, and then carried downwards gradually as it was wanted, provided we found that its continuation was practicable. Such an embankment at a suitable distance from the left bank of the Myitmaka would reclaim a large strip of country and save a considerable further strip from occasional inundations, which have in 1877 and 1880 reached nearly as far as the railway bank.

11. There is one other point mentioned in the Chief Engineer's note on which some misunderstanding seems to exist. It is suggested that the evil condition of the Yoma streams may be due to the deforestation of the Yoma slopes by *taungya* cutters. No doubt *taungya* cutters throw trees and branches into streams, and so help to block up the channels. But it certainly is not the case that the hills drained by these streams are bare, or anything like bare. In the first place, there is a continuous belt of reserved forest along the crest and down the western slopes of the Yoma. Most of these forests have been reserved and managed by the Government Forest Department for years past. Deforestation is certainly not going on inside the reserves. Then again such is the power of the soil and of climate that, even where *taungyas* are cut, a hillside is rarely bare for six months even. Almost before the *taungya* cutter reaps his crop the growth of a fresh jungle has begun on the land he cleared the previous summer. The fresh growth is indeed different in kind to the primeval forest, which is restored only after the lapse of generations, or may never be restored at all. But the ground is always covered with bamboos, or with growth of some kind. No one who has travelled about the Yoma can have failed to notice that on the rare occasions when a distant view is obtained through the trees a bare spot is hardly ever seen on the hillside. A thick bamboo growth marks the site of old *taungyas*, and the forest is usually different in kind where clearings have once been made. A Karen, when he returns after a lapse of seven years to his old *taungya* grounds, always finds a thick growth of bamboos or other jungle, which he cuts down and burns to fertilise the land. I do not at all wish to imply that the Yoma streams are not in need of care and conservation. I quite agree that the great jungle fires should be kept down and prevented if possible. As yet, unfortunately, we cannot keep down or prevent these fires in deciduous forests. But I believe that on the Yoma slopes above the Tharrawaddy plain there is not, and probably never has been, deforestation resembling the operations of man and of Nature, which have bared the slopes of the hills drained by the river Garonne.

12. * * * * *

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EXTRACT NO. 3

Taungnyo Stream, 1895

Report on a Proposed Diversion of the Kantha Stream by Mr. R. F. Bailey, Executive Engineer, Tharrawaddy Division, dated the 12th February, 1895

This report has been called for on account of a representation made by Mr. H. Slade, Deputy Conservator of Forests, Tharrawaddy Division, to the Conservator of Forests, Pegu Circle, No. 128C, dated the 31st August, 1894. Mr. Slade's report gives a complete account of what has happened at Thapangon by the Kantha bursting through its left bank at the village and flowing in a southerly direction towards Tapun, thus interfering with the floating of logs to the Myitmaka. Mr. Slade recommends making a cut at Thayetkon (a place about five to six miles east of Thapangon) towards Tapun with a view to make the Kantha take that course for the conveyance down of his timber. It is to show feasibility or otherwise of Mr. Slade's proposals that I have been called upon to examine the country and report on the scheme.

* * * * * *

From my trip the following information has been collected :—

(*a*) The Kantha stream in flood spills over its banks, both right and left, from the end of the existing embankments below the railway crossing as far as its inlet into the Kya-In fishery.

(*b*) The Shwele or Wetpok and the Kantha both discharge all their timber into the Kya-In fishery, whence it is removed at the south end and taken by one route to the Myitmaka.

(*c*) The Kantha stream flows along a ridge, as it were, and there is low-lying ground from Thayetkon to the Kya-In fishery on both banks of the stream, which is extensively irrigated by the ordinary floods of the Kantha.

(*d*) There is a line of high ground extending from Nattalin to Myenu village which is not crossed by the Kantha's spoil over its bank.

(*e*) The Tapun Chaung throughout its course is an ill-defined stream. It has two sources : (i.) The east source extends about fifteen miles east of the railway, where it is called the Zinza Chaung, lower down the Ledaw Chaung. It crosses the Nattalin-Kantha road at two and three-quarter miles from Nattalin. The bridge passed through is of timber of six spans of 10 feet each. Further on, near Myenu, the stream almost disappears, its section being only 10 by 2 feet, the water above being distributed over the adjacent fields. At Sengyaung village the stream was bunded up for watering cattle with a very substantial arrangement of stakes and earthwork. The section of stream measured 60 feet by 6 feet. (ii.) The other branch of the Tapun stream is called the Uboksinyo Chaung. It was formerly fed from the spill waters of the Kantha above Thapangon ; since the breach occurred at Thapangon all the Kantha water is running into it. The Uboksinyo Chaung meets the Tapun Chaung about half a mile east of Tapun. The combined waters are passed under the Tapun bridge, where is a timber structure of seven spans of 23½ feet each, giving a waterway of 164½ line feet by 17 feet average height. The Tapun Chaung below the bridge appears important for about a mile, but further down its waters spread

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over the low *kine-* (*kaing-*) covered country which extends down to the Myitmaka, into which the Tapun water drains by numerous small channels.

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I most strongly advise setting aside the proposal of Mr. Slade of making any cut at Thayetkon in order to bring forest logs *vid* Tapun into the Myitmaka. It will, I think, result in failure and loss to the Forest Department, much loss to cultivators, and some damage to the Tapun-Thapangon road. There is no well-defined stream into which the cut can be run until the Uboksinyo Chaung is reached. The flood water will spread over the gently sloping but even ground, destroying the crops in its downward course and leaving the logs broadcast over the fields, with every probability of their either getting buried in silt or otherwise lost. The only possible line is north of Myenu village into the Uboksinyo and thence to Tapun. A much better arrangement would be to encourage the outlet at Thapangon, whence the logs could much more easily reach Tapun. The greatest difficulty in any such arrangement would, however, I think, commence below Tapun. For the present I think the safest plan is to again close the breach at Thapangon with a substantial bank 160 feet long, 10 feet wide at top, side slopes of 3 to 1, average height 11 feet, allowing a 3-feet freeboard. The cost of the bank would not exceed Rs. 700 (£47). I think the whole trouble of the Kantha is due to the conflicting interests of the Civil and Forest Departments. The revenue authorities cut protective bunds and banks in order to feed their fisheries and irrigate their fields. The Forest Department want the water kept in a moderately deep and regular channel. The Forest Department cut more timber than they are able to pass down these streams in the one season, thus causing silting and raising bed level, resulting in a restricted waterway and spills over bank. To put a stop to these destructive arrangements, I would prohibit the tapping of such streams except by means of proper sluices placed at suitable points. I should prohibit the floating down of any timber after the end of August, leaving the September and October rainfall to sweep everything down to the low-lying land.

I believe these difficulties, *i.e.*, the conflicting interests of the Civil and Forest Departments, used to exist in years gone by east of (*i.e.*, above) the railway before the Kantha was embanked on both sides. At the present time matters are very different in this section of the river, and no complaints are received regarding it, unless indeed an abnormal flood comes down and breaches some weak point in the earthwork, an accident of rare occurrence. During the last two years, however, there has been no damage done, and the stream has been kept safely hemmed in its natural course.

The second step to be taken in the training of this river, treating the small matter of closing the breach at Thapangon as the first important undertaking, is the extension of the embankment down to Thapangon and even down to the Kya-In fishery. Once the water is conducted to this low-lying ground, the Forest Department's requirements will be fully complied with, as the water stands for a much longer period and gives the Forest Department more time to remove all the logs brought down. This was apparent to me when walking along the Kantha bank. There is scarcely a log at Monywagyi, while in the Kantha stream between Zegyaw and Thapangon there were hundreds. The cultivators will not be worse off than they are east of the railway, and probably

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the local rainfall will suffice for their requirements, but if Kantha water is indispensable for the fields and fisheries it should be given, as before stated, by means of proper sluices placed at suitable points.

I have carefully perused Colonel Scott-Moncrieff's note on the Tharrawaddy streams, and the conditions which now prevail in the Kantha seem identical with what was the case during his time. I do not think the cone of silt has advanced higher up the stream. As I before stated, during the last two years there have been no breaches in the embankment east of (*i.e.*, above) the railway, while such breaches were of frequent occurrence in previous years. The maintenance allowance for the embankment has practically remained the same.

EXTRACT NO. 4

Taungnyo (Kantha) Stream, 1903

Abortive Proposals of 1903 *for a Single Bund from the Railway to Tapun*

Letter, dated the 14th July, 1903, from the Executive Engineer, Tharrawaddy Division, to the Superintending Engineer, Pegu Circle, Rangoon

I have the honour to resubmit the estimate for proposed Kantha Chaung embankment with Deputy Commissioner, Tharrawaddy's memo., dated 3rd July, 1903 (and enclosures), for favour of disposal.

I take this opportunity to say that I invited the people of Thapangon (when I went there on the 10th instant to inspect the Tapun-Paungde road) to express their views on the necessity and benefits of the proposed work. They are unanimous in saying that any reclamation scheme, to be effective and permanent, must look to the training of the main drainage channel of the district, viz., Myitmaka Chaung, from its source to its confluence with the Irrawaddy, by making short cuts at the necks of long bends, etc. ; that the stream has been making a shorter channel for itself for some time past near Thapangon, with the inevitable result that the western detour has been left in favour of the shorter course through Tapun Chaung ; that there is a vast extent of culturable land not yet brought under cultivation, owing to regular inundation, and therefore not " pottaed," which will also be benefited if drainage of the place be improved ; and that a bund like the proposed one may improve a portion of land, but will surely cause flood in some other place to a more or less extent.

Note by Major Browning, Deputy Commissioner, Tharrawaddy, dated the 3rd July, 1903

I return you the estimate of the Kantha Chaung embankment, and I forward you a plan and a note and revenue statement by the Superintendent of Land Records, which illustrate clearly what small financial benefit will arise from the scheme.

As a revenue of less than Rs. 4,000 per annum will be derived as a result of the embankment, I cannot recommend the project.

I endorse every word of the Superintendent of Land Records' note, which has been written under my direction.

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It seems at least doubtful whether the embankment when made will have any beneficial effect whatever. What it saves in one direction it will probably ruin in another.

LETTER, DATED THE 25TH JULY, 1903, FROM THE SUPERINTENDING ENGINEER, P. W. D., BURMA

I have the honour to submit herewith a letter, dated 14th July, 1903, with enclosures, from the Executive Engineer, Tharrawaddy Division, together with plans and estimates amounting to Rs. 66,376 (£4,425) for constructing an embankment along the Kantha Chaung from near the Rangoon-Prome road to Tapun, in the Tharrawaddy District. The estimate has been countersigned by the Deputy Commissioner and Commissioner, and the Deputy Commissioner has subsequently given the financial aspect of the project.

2. I do not recommend the work, nor do I recommend that any more embankments of the Kantha Chaung be done. The state of things is not really very different from what it has been for many years, and I consider that, if any remedy is to be applied, the whole tract of the country to the west of the railway drained by the Myitmaka from its source to a point considerably south of the Kantha Chaung should be examined by a special officer with an adequate staff of surveyors. This would be rather an extensive job, and would take probably a whole dry season.

3. I think, however, it quite worth while that this should be done, as there are considerable Government interests involved both from the points of view of land revenue and of the Forest Department.

LETTER, DATED THE 5TH SEPTEMBER, 1903, FROM THE UNDER-SECRETARY TO THE GOVERNMENT OF BURMA, P. W. D., TO THE SUPERINTENDING ENGINEER, RANGOON CIRCLE

In returning unsanctioned the estimate amounting to Rs. 66,376, with plans and original correspondence, received with your letter dated the 25th July, 1903, for constructing an embankment along the Kantha Chaung from near mile 139 of the Rangoon-Prome road to Tapun, in the Tharrawaddy District, I am directed to say that, as the project is recommended neither by you nor the civil officers concerned, it is clear that the proposal would not relieve the evils complained of.

2. It is considered desirable that the whole question of flooding of land west of the railway should be inquired into, that longitudinal and cross sections of streams be taken to their outfalls into the Myitmaka and remedial measures considered in the light of information obtained by levels. I am to request you will arrange for the necessary surveys.

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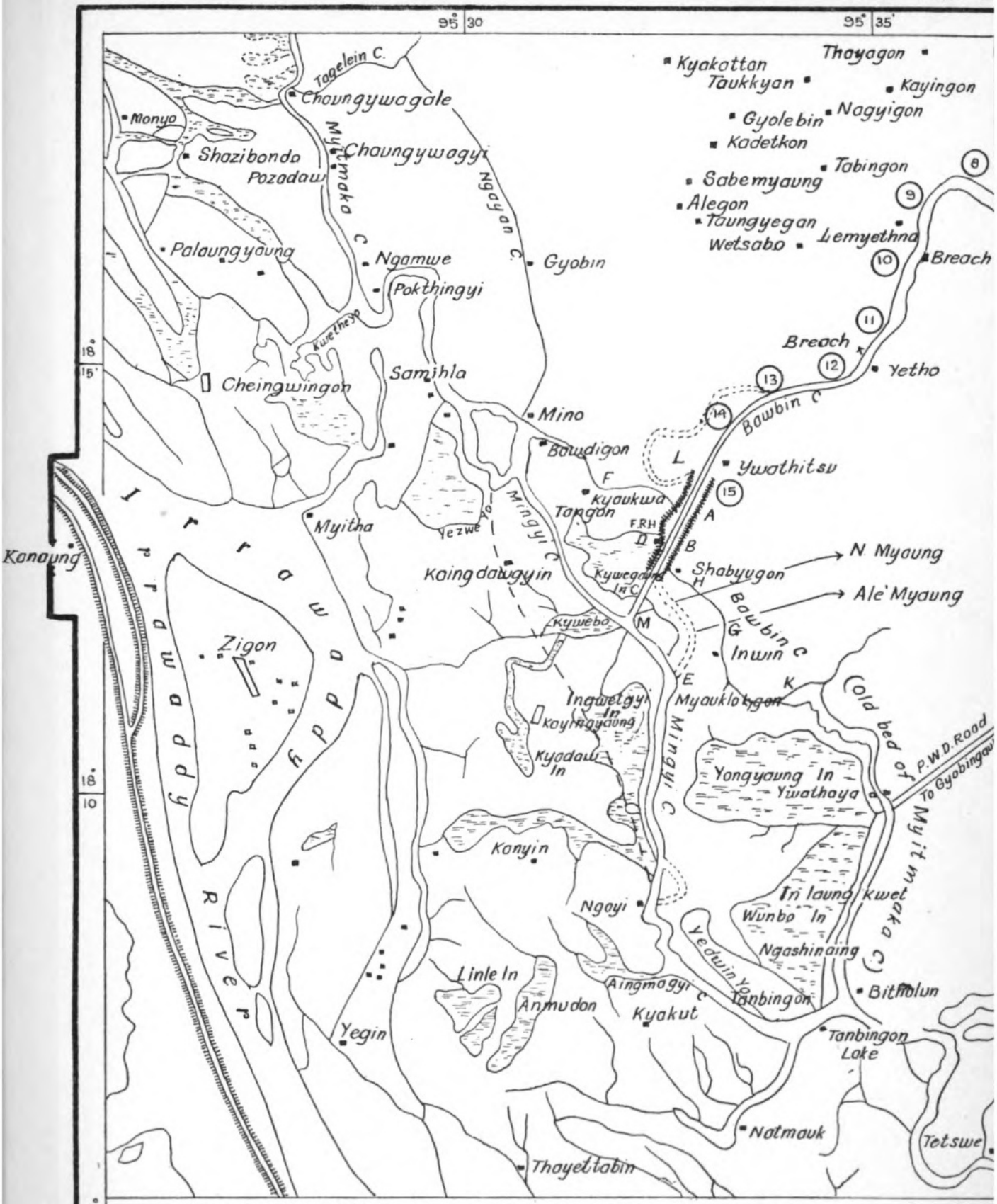

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Mileage from Railway ... ... (12)

Probable line of furture diversions of the Myitmaka ----

L.A. made in 1910-11.

A.C. " " 1915.

MAP OF MINGYI CHAUNG (MYITMAKA) AND BAWBIN STREAM

Scale 1 inch = 2 miles.

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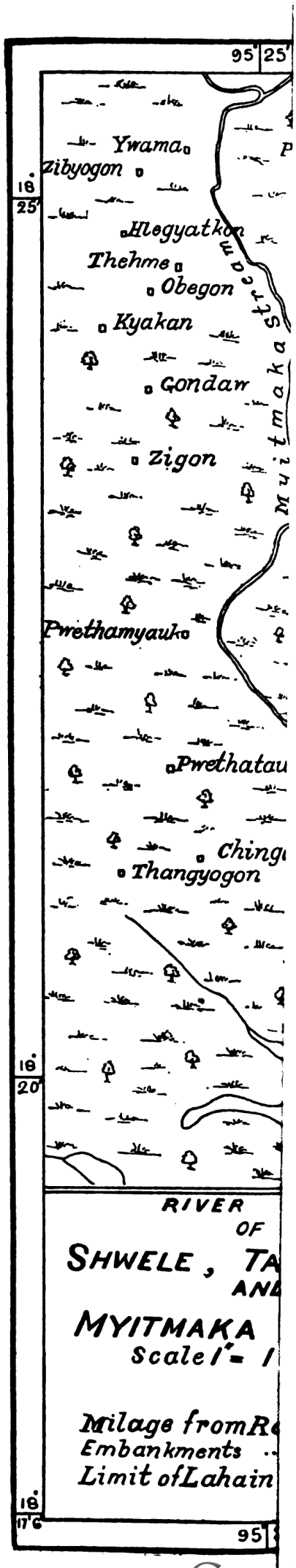

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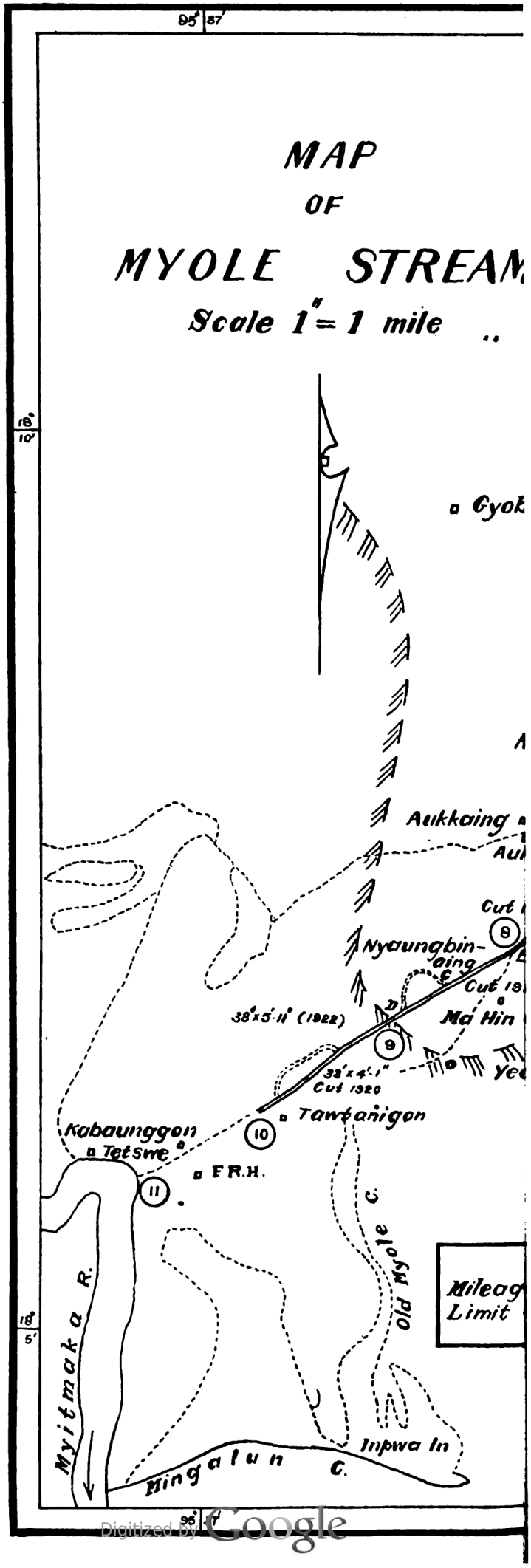

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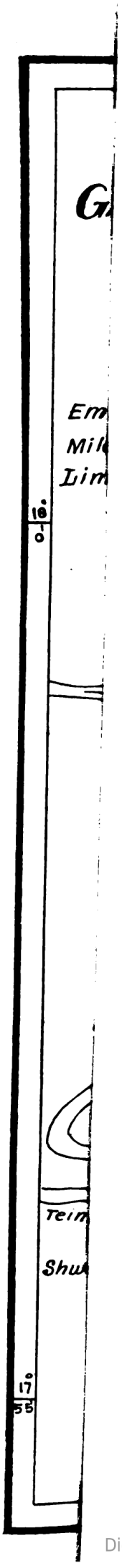

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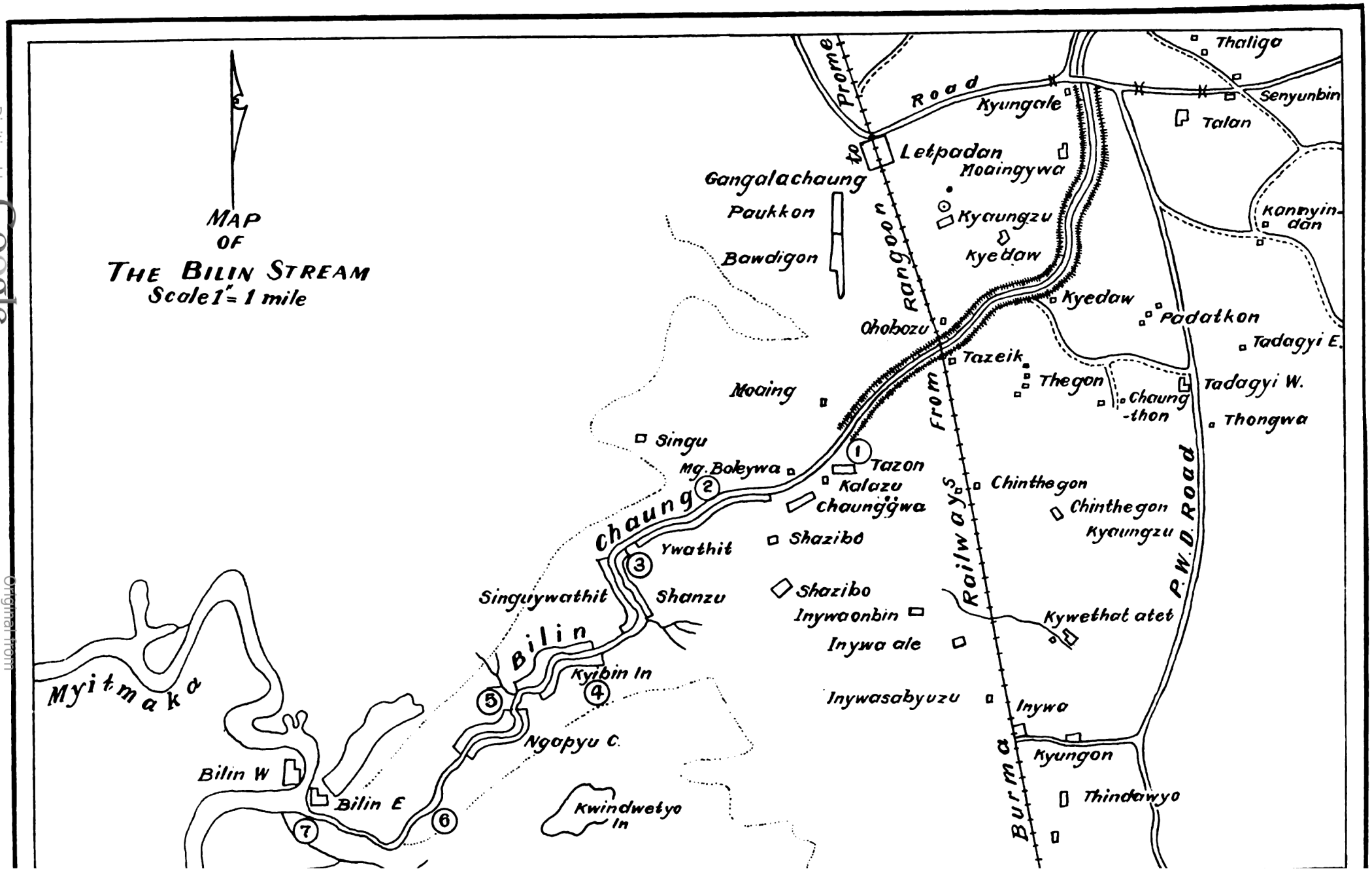

MAP No 10

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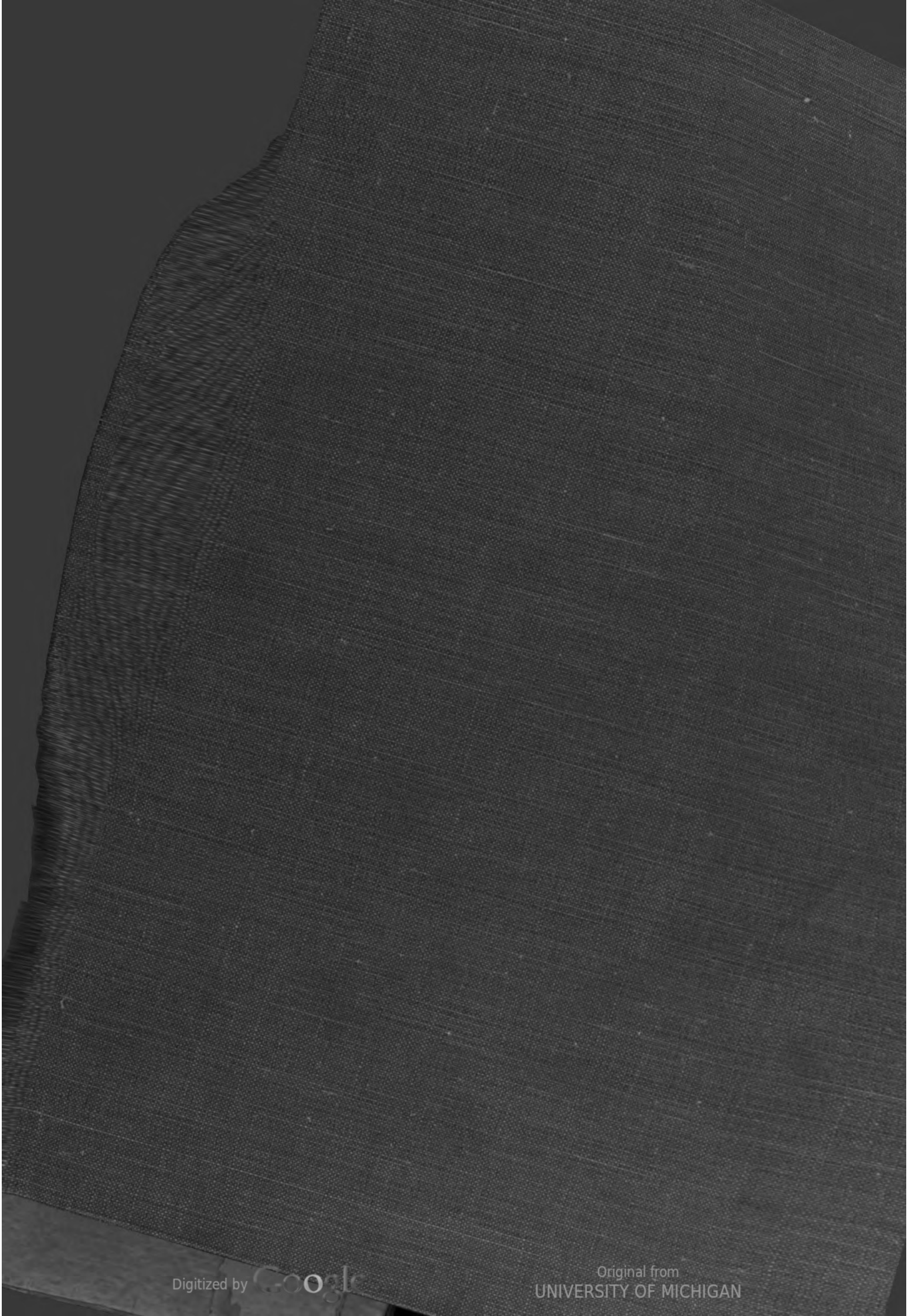
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